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LINEAR PERSPECTIVE

AND

MODEL DRAWING.

A

SCHOOL AND ART-CLASS MANUAL,

WITH QUESTIONS AND EXERCISES FOR EXAMINATION,

AND

EXAMPLES OF EXAMINATION PAPERS.

BY

LAURENCE ANDERSON.

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R. CLAY, SONS, AND TAYLOR, PRINTERS,
BREAD STREET HILL,
QUEEN VICTORIA STREET.

THESE lessons on Linear Perspective are intended for class use, and contain all that is necessary to give the student a complete view of the application of perspective law to the drawing, on a vertical plane, of an object in any given position.

All, or at least a large selection of the exercises on to Lesson 21, should be worked by those who are preparing for examination papers, similar to those of the Oxford and Cambridge Local Examinations; or the Second Grade papers of the Science and Art Department. To this should also be added a knowledge of the method of working shown in Lesson 30.

In the lessons on Model Drawing, the student will learn how to apply practically, to his outline sketch, the principles which he has mastered in the lessons on Linear Perspective. The aim here has been to induce method and awaken observation, by giving a firm hold of what is essential, and thus make the path plain as far as it extends. Careful practice will do the rest, as this ought to be the student's best instructor.

The lessons are arranged in the following order:

LINEAR PERSPECTIVE.

LESSSONS 1 to 5; 7 and 8; 10 to 14; 16 and 17; 20 to 24; 27 to 30.

MODEL DRAWING.

LESSONS 6, 9, 15, 18, 19, 25, and 26.

Ayr Academy, September, 1877.

LINEAR PERSPECTIVE AND MODEL DRAWING.

Lesson I.—Linear Perspective.

Perspective treats of the representation of objects as they appear to the eye.

Linear perspective is that branch of Mathematics which teaches how a drawing of an object may be executed with scientific accuracy so as to convey to the eye the same appearance as the object itself; and at the same time, it elucidates the principles which must direct the hand, in making a sketch from a group of models or from nature. It is the perspective of *lines;* and treats of the representation of the form and comparative size of objects, as these are observed from a given point.

Were you to trace carefully on an upright sheet of glass, an outline of the objects seen through it, your eye the while being kept quite stationary, a correct linear perspective drawing would thereby be obtained. Suppose you were looking seawards, with this large transparent plane of glass before you. You would have tracings of the boats and figures on the beach in the foreground, on the lower part of it; the tracings of the boats and ships out at sea would be a little higher up; the tracing of the horizon would be a straight line, right across the glass on a level with the eye; and above this would be outlines of the clouds. You would be able to trace on this transparent plane, in quite accurate drawing, as much of the scene as you could see easily without turning the head. This would be about 30 degrees all round the point right opposite the eye, called the **centre of vision** or **point of sight.** That is, you could easily take in everything within 30 degrees above the horizon, 30 degrees below it; 30 degrees to the right, and 30 degrees to the left of the centre of vision; 60 degrees—twice 30 degrees—being about the size of the angle which the eye can conveniently take in. A circle of that size described on the glass plane, from the centre of vision as centre, would mark about the limit beyond which you could not carry your tracing. Were you to trace any object much beyond this circle, the drawing in this part of your work would appear distorted.

That part of the tracing below the horizon line would be a perspective representation of the entire *sea*-surface and *ground*-surface lying beyond the transparent plane. This level surface is called the **ground plane,** and the line where the transparent plane and the ground plane meet is called the **ground line, the picture line, or the base line.**

Fig. I. represents a front view of this transparent or picture plane $FGNM$. The circle represents the **field of vision.** HL is the sight line or horizontal line, called here the **horizon line.** C is the **centre of vision,** and GN the **ground line.**

Fig. II. is a representation of the same **transparent plane,** so drawn as to show S the **station point** where the spectator's eye is supposed to be. The line SC represents the direct distance of the spectator from the transparent plane, and is called the **central line of vision** or line of direction. HL is the **horizon line,** C the **centre of vision,** GN the **ground line,** where the transparent plane rest son, or intersects, the **ground plane** $ABDE$; and ST is the height of the eye above the ground.

Questions.

1. What is the horizon line? 2. What is the ground line? 3. Give another name for the ground line. 4. What is the line of direction? 5. Give another name for the line of direction. 6. What is the centre of vision? 7. Give another name for the centre of vision. 8. What is the station point? 9. What is the name of the line which extends from the station point to the centre of vision? 10. What is the relation of the transparent plane to the ground plane? 11. What does the horizon line on the transparent plane represent? 12. What does the circle on the transparent plane represent? 13. What does the centre of this circle on the transparent plane represent? 14. What angular measurement can the eye conveniently take in? 15. What is meant by the height of the eye?

Fig. I.

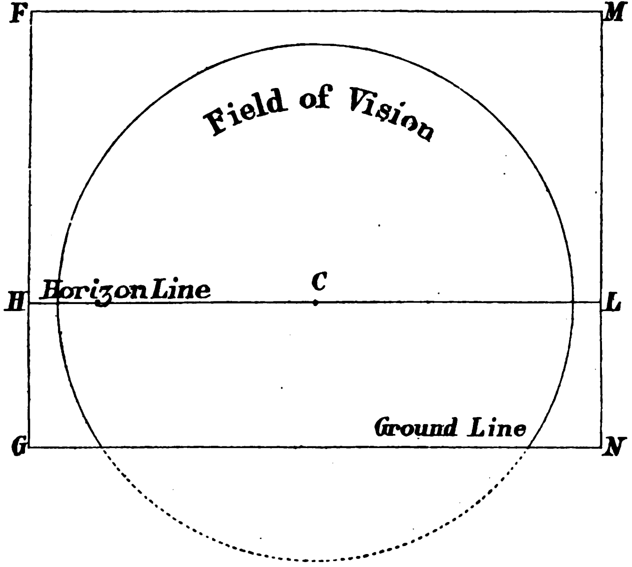
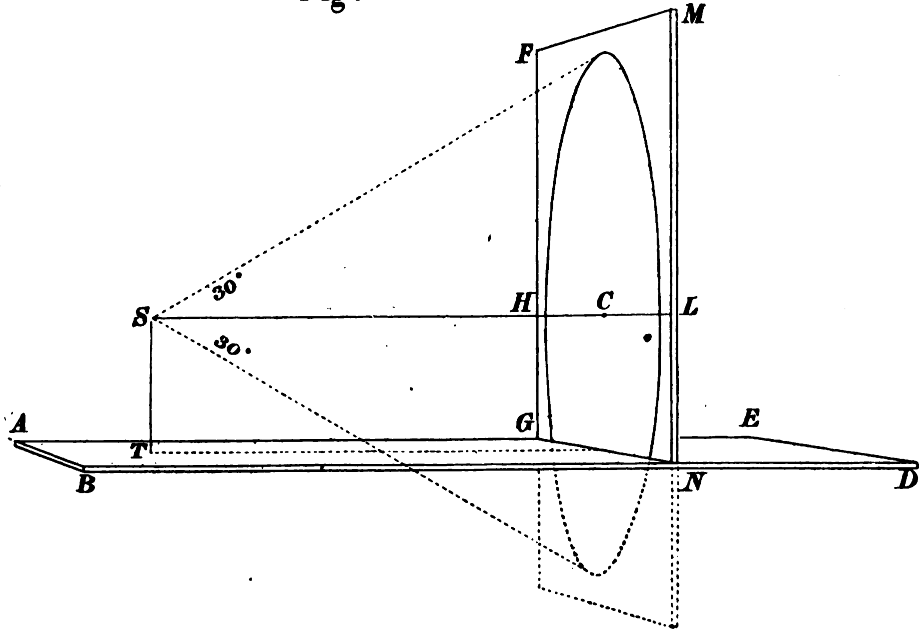

F
M
Field of Vision
H
Horizon Line
C
L
Ground Line
G
N

Fig. II.


M
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30°
30°
S
H
C
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A
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B
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D

LESSON II.—Linear Perspective.

In the previous lesson you were supposed to be looking out to sea, through an upright transparent plane. It is evident that tracings thereon of ships near the horizon would be smaller than the tracings of ships near the shore, and that a tracing of a boat out in the bay would be smaller than the tracing of a boat of the same size on the beach. In any case, the size of the tracings would be much smaller than the objects themselves. But, suppose you have placed your large transparent plane right up against a post for support, it is clear that the tracing of this upright post which touches the glass plane would be exactly of the size of the post itself; and were other two upright posts of equal size so placed that the one is twice and the other three times the distance from you, of that which is close to the glass, it would be found that the tracing of the furthest is almost exactly one-third, and the tracing of the middle one almost exactly one-half the size of the tracing of the first. Thus you would discover that objects appear to diminish in proportion to their distance from the spectator; and that when they are *at*, or touching, the transparent plane, they are to be represented of their real size. See Fig. I. and Fig. II.

In making the supposed tracing of any object as seen through the transparent plane, you simply *intercept* the several rays of light, as they come in straight lines *through* the plane from the various points of the object to the eye; and hence the entire circle on the plane may be considered as the base of a cone of rays, of which the apex is the eye. Fig. II. illustrates this *interception*, on the transparent plane ($F\,G\,N\,M$) of the rays from the top and bottom of the vertical posts X and Y. The lines $x\,x$ and $y\,y$ are the heights of their respective tracings on the plane.

By referring to Fig. III. it will be observed that by fixing on the point S as the distance ($S\,C$) from the transparent plane, the size of the circle, or field of vision on the plane, is thereby determined. Were you to retire to the point O, the circle would be enlarged, and were you to advance to the point P, it would be diminished.

By tracing (Fig. IV.) the scene on a *given portion* of the transparent plane, you would get fewer objects into your drawing from the station-point C than you would get from the station-point B; and again by tracing from B as a station-point, you would get fewer objects into your drawing than from the station-point A; but the tracings of the individual objects in the scene would be larger in size when taken from the station-point B than from the station-point A, and larger still when taken from the point C. If this is not evident, try the experiment on a pane of the window, when you will also discover that one eye only must be used in making such a tracing.

In actual practice in model drawing, your sketch book or drawing-board will always be some portion of the circle on the transparent plane.

Questions.

1. In making a tracing such as is supposed in this and last lesson, why do you require to keep the head quite still? 2. Explain how you are able to make a tracing on a pane of the window of an object seen through it? 3. Of two cups of equal size on the table, the one being six feet off and the other four, which would be made the larger on a drawing that included both? 4. Suppose you traced the two cups on an upright sheet of glass, placed exactly half way between you and the nearest, what proportion would the near one bear to the other on the tracing? 5. What is it that determines the size of the circle, or field of vision on the transparent plane? 6. If you retire from the transparent plane, what effect has this on the size of the tracings on this plane, of objects seen through it? 7. What effect has it on the number of objects you can include, on (say) a square foot of the transparent plane? 8. With reference to this transparent plane, how is your sketch-book or drawing-board to be regarded?

Fig. I.

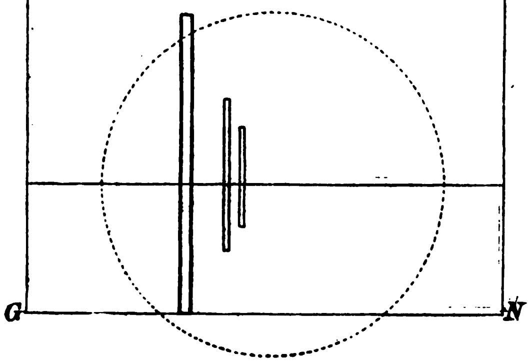


Fig. II.

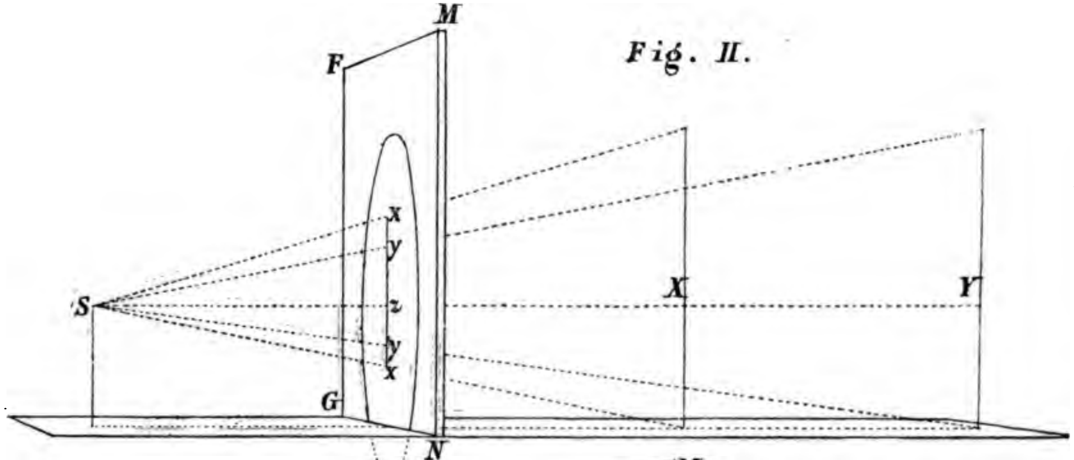


Fig. III.

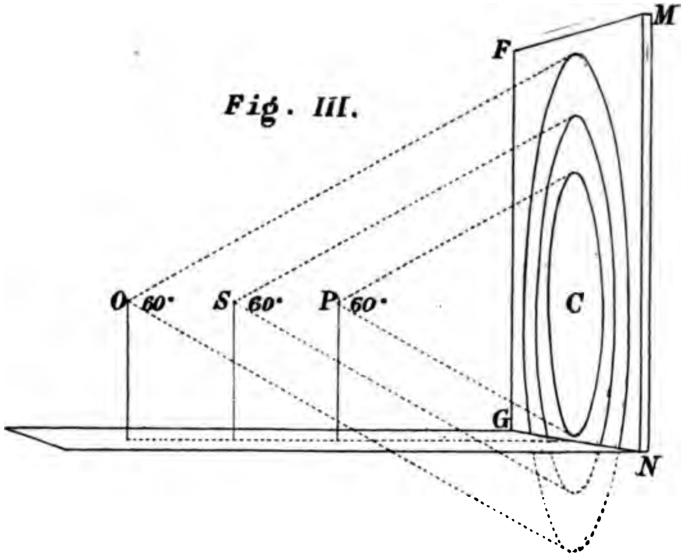
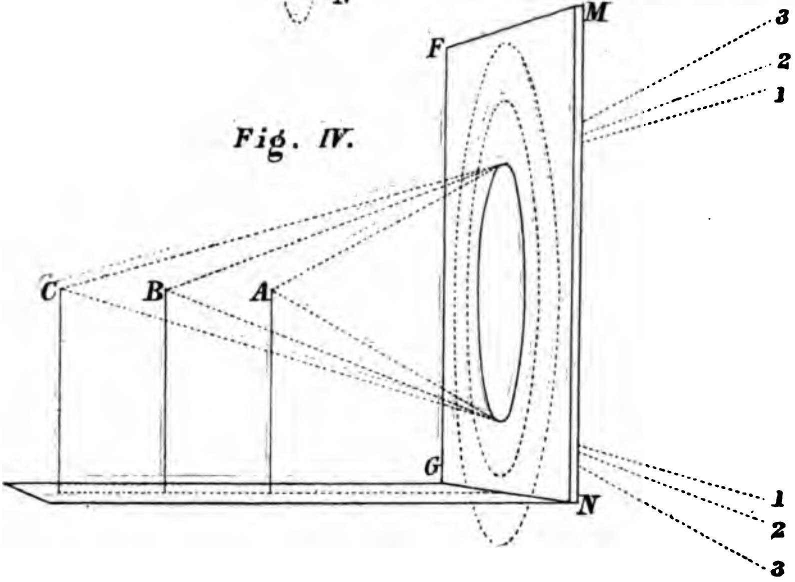


Fig. IV.



LESSON III.—Linear Perspective.

SUPPOSE you were looking along a straight, level street, and made another tracing. You would first determine your station-point, or the distance you were to stand from the transparent plane, and then the centre of vision on that plane. The station-point would determine the size of the field of vision on the plane, and the centre of vision would determine the horizon-line. On examining such a tracing you would find that all the straight lines in the street which are parallel to the central line of vision, that is to the direction in which you were looking, have their tracings all pointing, or converging to, the centre of vision; such as the horizontal lines of the roofs, lines of cornices, the top and bottom lines of windows and doors, the basement lines of the walls, the gutter-lines of the pavement, and the tramway lines in the middle of the roadway. Were you to produce these lines on your tracing on the glass, it would be found that they all meet in the centre of vision, those above the horizon-line sloping downwards, and those below the horizon-line sloping upwards to that point. This point is therefore called the **vanishing-point** of these lines, and by this experiment you would find that the centre of vision is the vanishing point of all lines which are parallel to the central line of vision. On the other hand, the vertical lines in the street such as the sides of doors and windows are represented by vertical lines in the tracing, and any horizontal lines that are parallel to the transparent plane, that is, lying right across the street, or such as horizontal lines on the end walls, are represented by horizontal lines on the tracing. Hence it follows that lines which are parallel to the transparent plane appear parallel, and consequently have no vanishing point. It would also be found that not only do the doors, windows, and objects in the street diminish in proportion to their distance, but that those lines,—such as lines of cornices, &c.,—which have one end of them nearer to you than the other end, are shortened by reason of this position. Such lines are said to be *foreshortened* (Fig. I.).

Planes.

1. A plane may be defined as an *even* surface on which a straight edge, when applied to it, will coincide in any direction. It is of no thickness, and an edge view of it is a line. It is to be conceived as of unlimited extent.

2. A horizontal plane is a level surface, as the floor or ceiling of a room. An edge of it is a horizontal straight line (Fig. II.).

3. A vertical plane is an upright even surface, as the side or end wall of a room. An edge view of it, when looked at horizontally, is a vertical straight line (Fig. III.).

4. An oblique plane is one which is neither horizontal nor vertical, as the sloping surface of a roof. When the line of vision coincides with the plane, it then appears an oblique straight line.

Questions.

1. Suppose you stand in the middle of a level street, and look towards the far end. In a sketch from this position which lamp-post would be made highest? 2. Which two would be placed closest together in such a sketch? 3. In what direction would the basement line of the wall on the left hand be drawn? 4. How would a cornice line near the top of the wall on the right hand be represented? 5. How would a horizontal line be represented when on a level with the eye and at right angles to the transparent plane? 6. How would it be represented when parallel to the transparent plane? 7. What is the vanishing point of all lines at right angles to the transparent plane? 8. What is meant by a foreshortened line? 9. Give an example (or arrange one) from the place where you are sitting. 10. What is a plane? 11. What is a horizontal plane? 12. What is a vertical plane? 13. What is an oblique plane? 14. Suppose you look down on a vertical plane so as to have an edge view of it, how would you represent such a view? 15. What determines the height of the horizon-line on the transparent plane?

Fig. I.

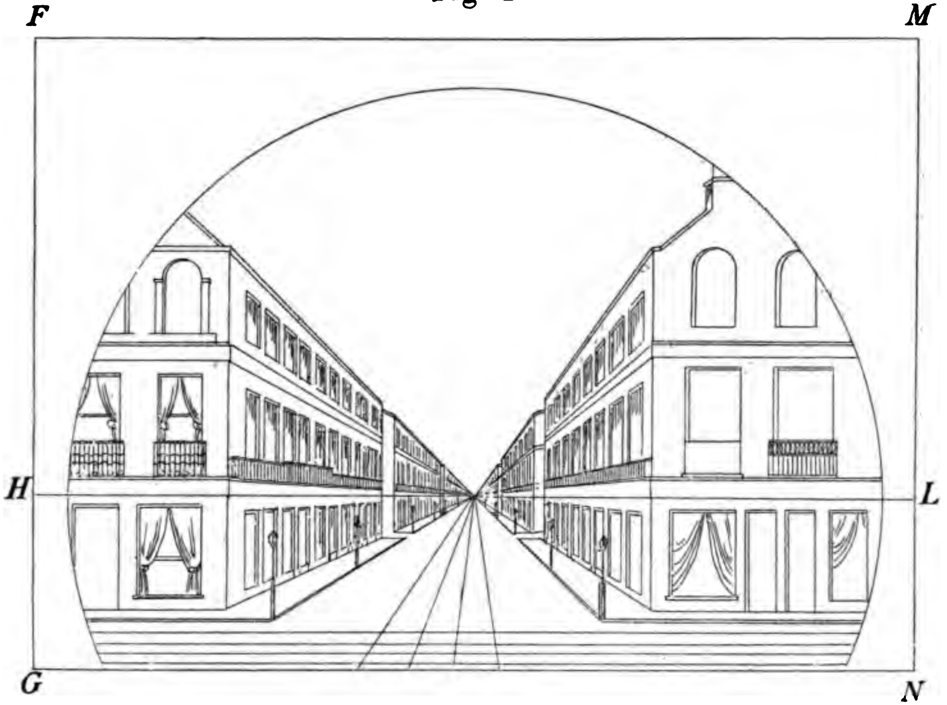


Fig. II.

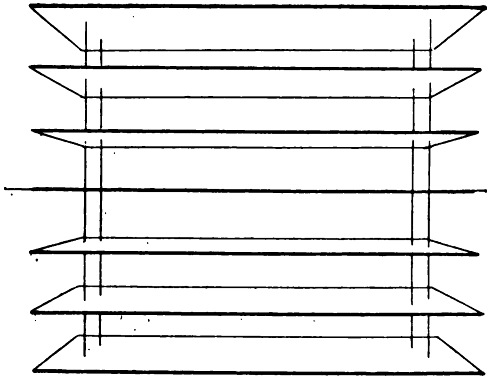
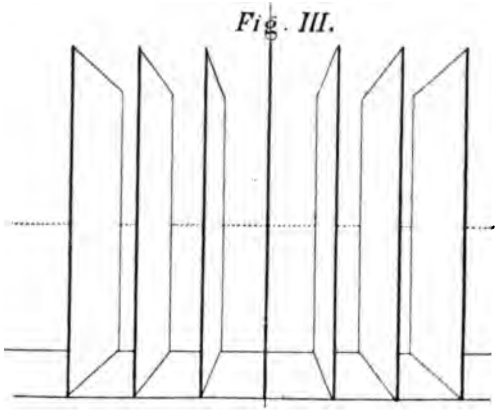


Fig. III.



LESSON IV.—Linear Perspective.

IN the foregoing lessons you were supposed to trace your drawing on a vertical plane of glass. In this, you proceed to learn how to execute it on paper; and first, you have to prepare your paper for that purpose.

Let *A B D C*, Fig. I., represent your sheet of paper. Construct a scale as shown. With your T-square draw a line across the paper as *G N*. This line represents the ground-line, and is an edge view of the ground plane, where it intersects at right angles the plane of the picture. All above this line is the transparent or picture plane. All below it is a continuation of the same plane, on which are made certain constructions necessary for working a perspective problem. At the height of the eye, above the ground, draw another line parallel to the first, to represent the horizon line as *H L*. The space between these two lines is a *perspective representation* of the ground plane, extending from *G N* out to the horizon *H L*. The horizon-line itself should be regarded as an *edge view* of a horizontal plane, on a level with the eye. On this horizon-line, and at or near the middle of it, mark the centre of vision (*C*), directly opposite which the eye is supposed to be. As you cannot here represent the central line of vision in its true position,—which you know to be at right angles to the picture plane, that is coming straight out from the centre of vision,—draw it at right angles to the horizon-line, either above or below it. It will generally be found more convenient to draw it downwards, as *C S*. Make *C S* equal to the distance of the spectator from the picture plane. Next draw a line through *S* parallel to *G N*, to enable you, with the aid of the protractor, to draw lines from *S*, at any angle, to *S C* or *G N*. From *S* draw a line *S B* at 30 degrees to *S C*, which gives *C B* the radius of the circle representing the field of vision. From centre *C*, with radius *C S*, cut *H L* in the points D^1 and D^2. These points are called the points of distance, and are very important. They may also be found by drawing a line from *S* at 45 degrees as shown. The paper is now prepared (Fig. I.) for working any problem in what is called parallel perspective; that is, the perspective of objects which have one set of lines parallel to the central line of vision, and another set parallel to the picture plane.

Fig. II. represents the picture-plane in elevation, with two objects represented thereon, in perspective. In Fig. III. you have the picture-plane *H L*, the two objects *X* and *Y*, the station-point *S*, the central line of vision *S C*, the field of vision *B K*, and the cone of rays *B S K*, all represented in plan; as if you were looking down on them. The points 1, 2, 3, and 4, 5, 6, mark the points where the rays of light, coming from the several points in the objects *X* and *Y*, to the eye at *S*, are intercepted on the picture-plane. The distances between these points 1, 2, 3, and 4, 5, 6, give the perspective widths of the corresponding sides of the objects in Fig. 2.

Questions.

1. Mention the several lines and points which you determine on your paper, preparatory to the working of any problem in parallel perspective. 2. What is the true position of the central line of vision with reference to the picture plane? 3. How do you represent the central line of vision on your paper? 4. What does the space between the picture-line and the horizon-line represent? 5. How do you find the points of distance? 6. How do you determine the radius of the circle (or field) of vision? 7. Figs. II. and III. are two representations of the same thing, viz., the picture-plane and two objects, together with the necessary lines required. Compare the one with the other so as to show that these are understood. 8. What does the picture-plane *F G N M* in Fig. II. become in Fig. III.? 9. How is the central line of vision (*S C*) in Fig. III. represented in Fig. II.? 10. How is the station-point *S* in Fig. III. represented in Fig. II.? 11. What does the triangle *B S K* represent? 12. How is the point *B* found? 13. What do the measurements 1, 2; 2, 3; 4, 5, and 5, 6 represent? 14. Do you observe how the measurements 1, 2, and 2, 3, &c., are transferred to the objects in Fig. II.?

Fig. I

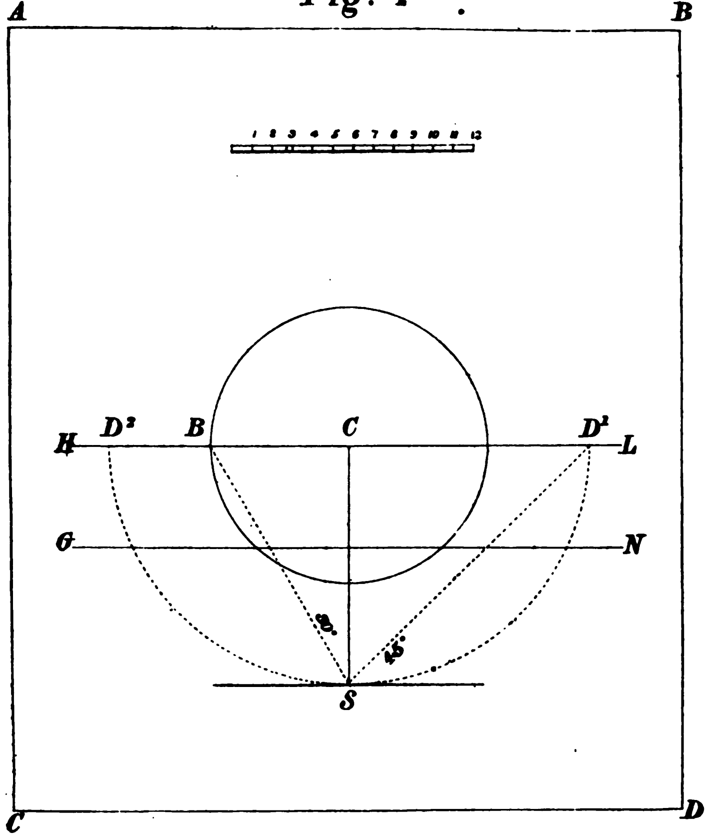
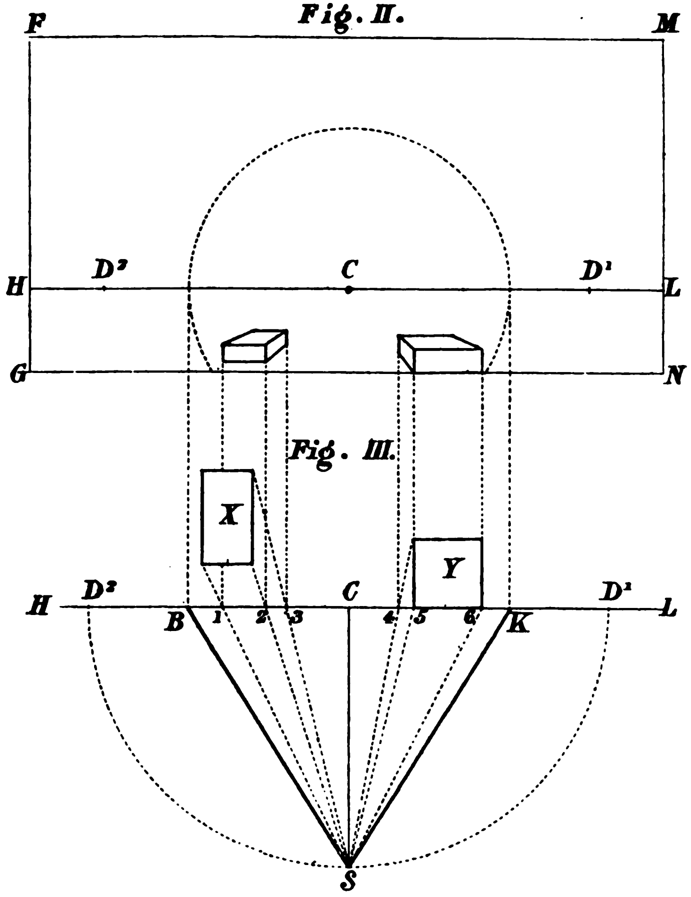


Fig. II.

Fig. III.



LESSON V.—Linear Perspective.

A SQUARE sheet of iron, 3 feet side, is united at right angles to another square sheet of the same size, edge to edge. One lies flat on the ground, and the other stands upright. One edge of each touches the picture-plane, and the corner B of the nearest is 2 feet to the right of the centre of vision. The station-point is 12 feet from the picture-plane, and the height of the eye above the ground is 5 feet.

Make $o B = 2$ feet, and $B E = 3$ feet. This is the length of the edge on the ground, touching the picture-plane. Make $E F = 3$ feet, at right angles to $B E$. This is the edge of the upright sheet which touches the picture-plane. From points F, E, and B draw lines to C. From B measure 3 feet to A. From A draw $A D$, cutting $B C$ in K. From K draw $K J$ parallel to $B E$; and from J draw $J G$ at right angles to the ground-line, and the drawing is completed.

It will be observed that by means of the point of distance (D), you can cut off any perspective length from a line ($B C$) at right angles to the picture-plane. This is done by measuring its real length on the ground-line from B to A, and joining $A D$. The real size is measured here, as always, on the picture-plane, and transferred to the retiring-line. Had you wished to cut the 3 feet from $E C$, you would have measured 3 feet to right or left of E, and from the point found, drawn a line to the opposite point of distance. Had you wished to cut 3 feet from $F C$, since $F C$ does not lie on the ground-plane, but in a plane 3 feet above it, you would have required to draw a line through F parallel to the ground-line, on the picture-plane, to represent an edge view of the horizontal plane in which the line $F C$ lies. On this edge view (or base-line) you would have measured from F, 3 feet to the right or left, and from the point found drawn a line to the opposite distance-point.

The space between $B C$ and $E C$ represents a horizontal plane, on the level of the ground, 3 feet wide and of infinite length, whose nearest edge is $B E$. The space between $E C$ and $F C$ represents a vertical plane, resting on the ground on its edge $E C$, in height 3 feet, and of infinite length, whose nearest edge is $E F$. Therefore any line drawn parallel to $B E$, between $B C$ and $E C$, would represent a line 3 feet long, and any line drawn parallel to $E F$ between $E C$ and $F C$, would represent one 3 feet high.

A straight rod, 8 feet long, lies on the ground at right angles to the picture-plane, its nearest end being 2 feet to the right of the centre of vision, and 3 feet into the picture. Draw the rod.

It is clear that the rod will lie on the retiring-line $B C$. From B measure 5 feet to the left in L. Make $L M = 8$ feet. From L and M draw lines towards D, till they cut the line from B to C, in the near and far end of the rod.

Place a vertical rod 3 feet high in any given point as d. Draw $d a$ parallel, and $a b$ at right angles to the ground-line; $b c$ parallel, and $d c$ at right angles to the ground-line; $d c$ is the line required.

Exercises.

NOTE.—In the following exercises the station-point is supposed to be 12 feet from the picture-plane, and the height of the eye 5 feet.

1. A straight rod 6 feet long lies on the ground, 4 feet to the right of the centre of vision, and at right angles to, and touching the picture-plane.

The rod lies 5 feet to the left, is at right angles to the picture-plane, and is moved 3 feet into the picture.

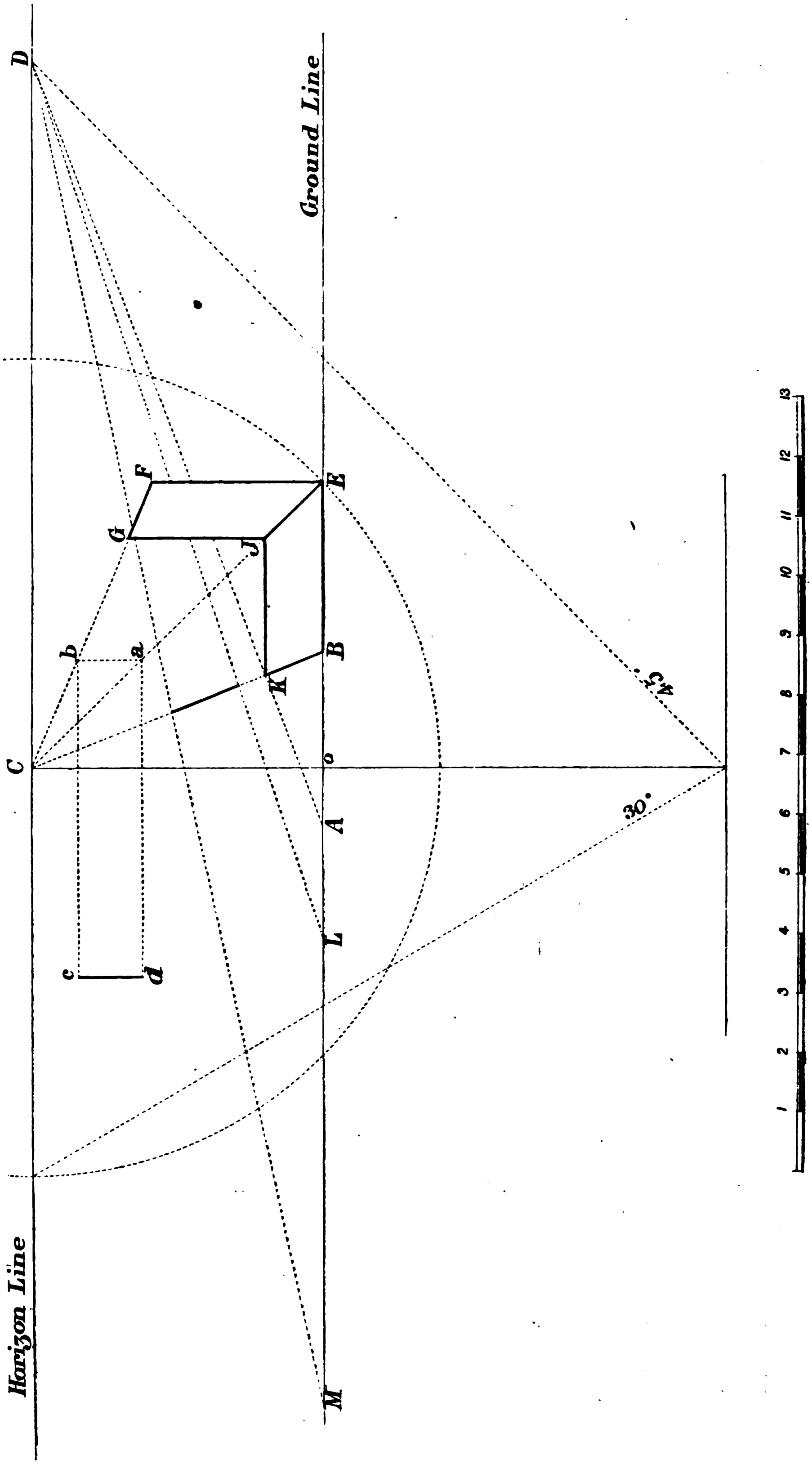
3. The rod lies parallel to the picture-plane, 3 feet into the picture, the left end of it being 2 feet to the right of the centre of vision.

4. Five rods, each 4 feet high, stand upright in a row, parallel to the central line of vision, and 2 feet apart. The nearest rod touches the picture-plane, 4 feet to the left.

5. The above five rods are laid down towards the right, flat on the ground, parallel to the picture-plane, the end of each touching the point where it stood.

A square 3 feet side is on the ground-plane; one side touches the picture-plane, and the right corner is 2 feet to the left.

NOTE.—It will be found on trial, that the points of distance are the vanishing-points of the diagonals of a square lying in a horizontal plane, when one side is parallel to the picture-plane. The points of distance are thus seen to be the vanishing points of horizontal lines at 45 degrees to the ground-line.


Horizon Line
Ground Line
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45°
30°
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3
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LESSON VI.—Model Drawing.

AN object is seen by means of rays of light, which come from every visible point in straight lines to the eye, as in Fig. I. A perspective drawing of an object is therefore a section of these rays. An edge view of such a section plane is seen at *B*.

The angle which an object subtends at the eye, as the angle at *C* which is subtended by the rod *A B* in Fig. II., is called the visual angle. The size of such an object is determined by the size of this angle.

The size of the visual angle of an object is changed either by *distance* or by *position*. Fig. III. illustrates the change that takes place in the visual angle of the rod *A B* by reason of its distance from the eye at *S*. Fig. IV. illustrates the change of the visual angle occasioned by the position of the rod *D E*.

To apprehend the change in the visual angle, and consequently the change in the apparent size of an object occasioned by *distance*, make the following experiment. Take two drawing-pencils of equal length, one in each hand, and hold them up at right angles to the line of vision, having the one a few inches from the eye, and the other at arm's length. It will be seen that the near pencil appears longer than the one more distant. The near one subtends at the eye a larger angle than the other. Transpose the pencils, and a similar effect will be observed.

To apprehend the change in the visual angle occasioned by *position*, and consequently the change in the apparent size of the object, perform the following experiments:—

First. Hold your pencil in a horizontal position on a level with the eye, so as only to see the end of it. Call this the *first position.* Turn the pencil slowly round from right to left, parallel to the floor, and observe the change in the apparent length of the pencil, till it comes parallel to the face, when it will be seen of its real length. From the first position again turn it round slowly from left to right, and note the changes as before.

Second. Bring the pencil to the first position. Keep it horizontal, and raise it a few inches above the level of the eye. In this position the far end will appear straight below the near end. Turn it slowly round, first to the right and then to the left as before, and carefully note the changes that take place, *both* in its direction and apparent length.

Third. Bring the pencil to the first position. Keep it horizontal, and lower it to a few inches below the level of the eye. The far end will now be seen straight above the near end. Turn it slowly round, first to the left and then to the right, and carefully note the changes that take place *both* in its direction and apparent length.

Fourth. Hold out the pencil in front of you, at right angles to the floor, and also at right angles to the line of vision. Call this the *second position.* Turn the pencil over slowly till it comes down to the first position. Continue the motion, till it comes round again to the second position, and observe the while the changes that take place.

Fifth. Bring the pencil to the second position. Turn it over *from* you, towards the right, till it comes down to a horizontal position, and at half a right angle to a pencil in the first position. Continue the motion till it comes round again to the second position. Let this be done slowly, so that the direction and apparent size of the pencil may be carefully noted.

Practise now from a straight rod 3 or 4 feet long. Let it be fixed on a model-stand, so that it may be easily placed, in regular succession, in the several positions indicated above. A second rod, of equal length, must be fixed in a vertical position near the other, in order that a constant comparison may be made between the apparent length and apparent direction of the moveable rod, and the real length and real direction of the stationary one. A vertical line of given length should be drawn on the paper, to represent the fixed rod, so that a similar comparison may be made on the drawing.

In making comparisons of length, adopt the following method. Hold out your pencil at arm's length, at right angles to the line of vision, and take the measure of the moveable rod between the end of the pencil and the thumb-nail. Compare at arm's length this *pencil measurement* with the length of the vertical rod, by bringing the pencil directly between it and the eye. Note the proportion, and make your drawing thus to correspond with the given vertical line on your paper.

After some facility has been acquired in this practice, a course from wire models should be systematically gone through.

Fig. I.

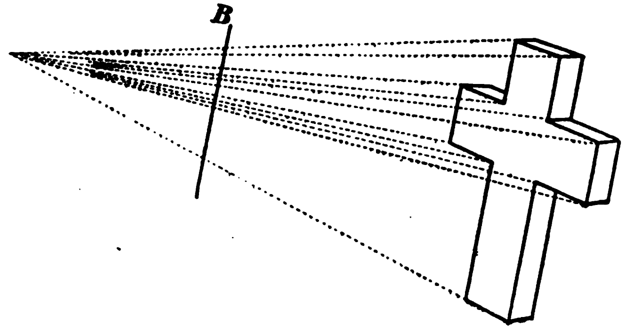


Fig. II.

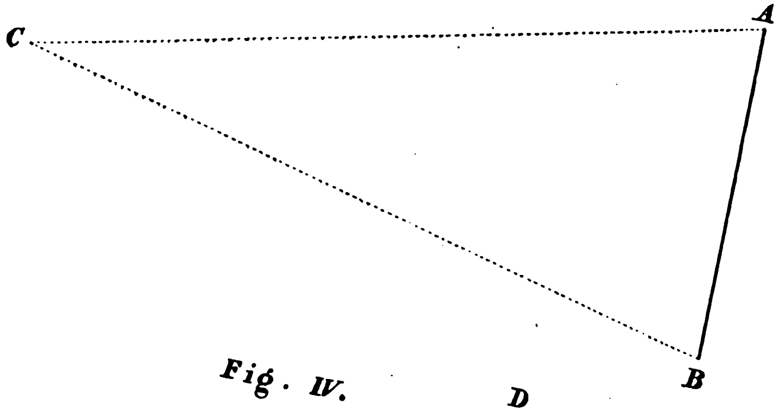


Fig. III.

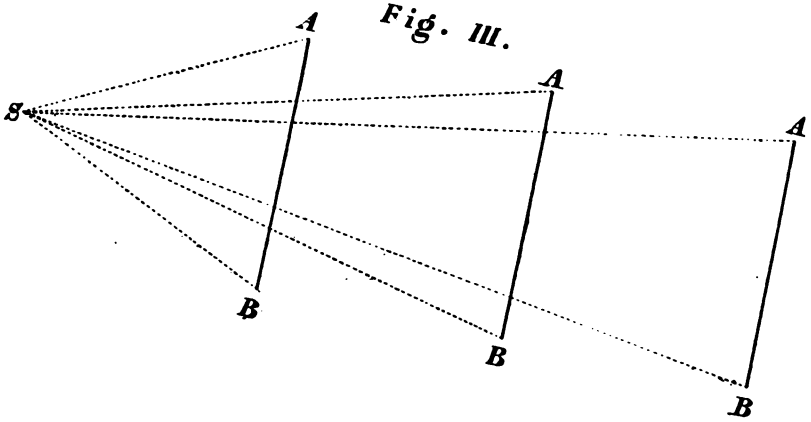
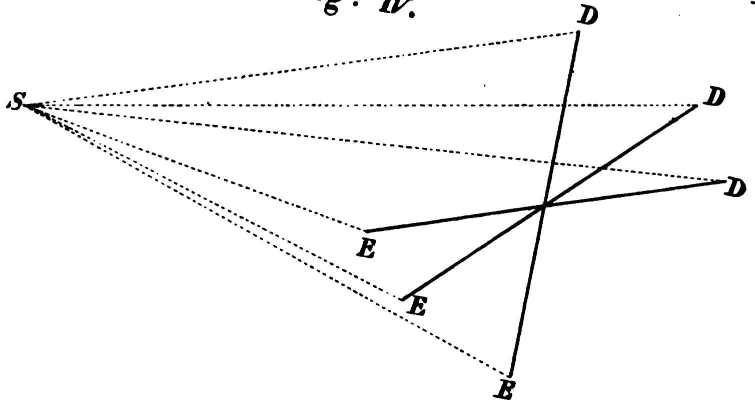


Fig. IV.



LESSON VII.—Linear Perspective.

General Principles.

1. The horizon-line is the vanishing-line of all horizontal planes; and all horizontal lines have their vanishing-point somewhere on the horizon-line.

2. A vertical line, drawn through the centre of vision, is the vanishing-line of all vertical planes parallel to the central line of vision.

3. The centre of vision is the vanishing-point of all lines parallel to the central line of vision.

4. Lines which are parallel to the picture-plane have no vanishing-point.

5. Horizontal lines must be conceived as lying in horizontal planes.

6. Vertical lines must be conceived as being in vertical planes.

7. The points of distance are the measuring-points of all lines which are parallel to the central line of vision.

8. The centre of vision is a measuring-point of all lines parallel to the picture-plane.

9. All real measurements are made on the picture-plane, and are reduced to their perspective dimensions by means of their measuring-points.

10. Any vertical measurement on the drawing bears the same proportion to the corresponding vertical measurement on the object, which the distance of the picture-plane from the station-point bears to the distance of the object from the station-point.

It may be expressed thus :—

Any measurement on the drawing, parallel to the picture-plane, bears the same proportion to the corresponding measurement on the object, which the distance of the picture-plane from the station-point bears to the distance of the object from the station-point.

For example, in Lesson II., Fig. II.

The line $x x$ is to the vertical line X as $S z$ is to $S X$, or

The line $y y$ is to the vertical line Y as $S z$ is to $S Y$ (Euc. VI., 6).

The drawing on the plate is that of a log, 12 feet long, with a square end 2 feet side, which lies at right angles to the picture-plane, the left side being 2 feet to the right of the centre of vision, and the near end being $2\frac{1}{2}$ feet from the picture-plane. The station-point is 12 feet from the picture-plane, and the height of the eye is 5 feet.

Construct on $E G$ a square 2 feet side, having the point E 2 feet to the right. From the corners draw lines to C. Make $E 4 = 2\frac{1}{2}$ feet, the distance of the end of the log from the picture plane. Make $4, 5 = 12$ feet, the length of the log. From 4 and 5 draw lines towards D, meeting the line $E C$ in a and b. From a and b draw vertical lines to meet the upper edge, and from the points found draw horizontal lines. From a draw a horizontal line to meet the retiring line $G C$, and from the point found erect a vertical line to complete the drawing.

It is not necessary to construct a square on $E G$, as here shown. It is evident that a single vertical line of 2 feet to scale, erected either at E or G, would have been sufficient.

Observe how $2\frac{1}{2}$ feet into the picture from E is found, and also how the length of the log, 12 feet, is transferred from the picture-line to the retiring-line $E C$.

Exercises.

1. Draw the log in the plate $2\frac{1}{2}$ feet to the left of the centre of vision, but having its end touching the picture-plane, the distance and height of the eye being the same.

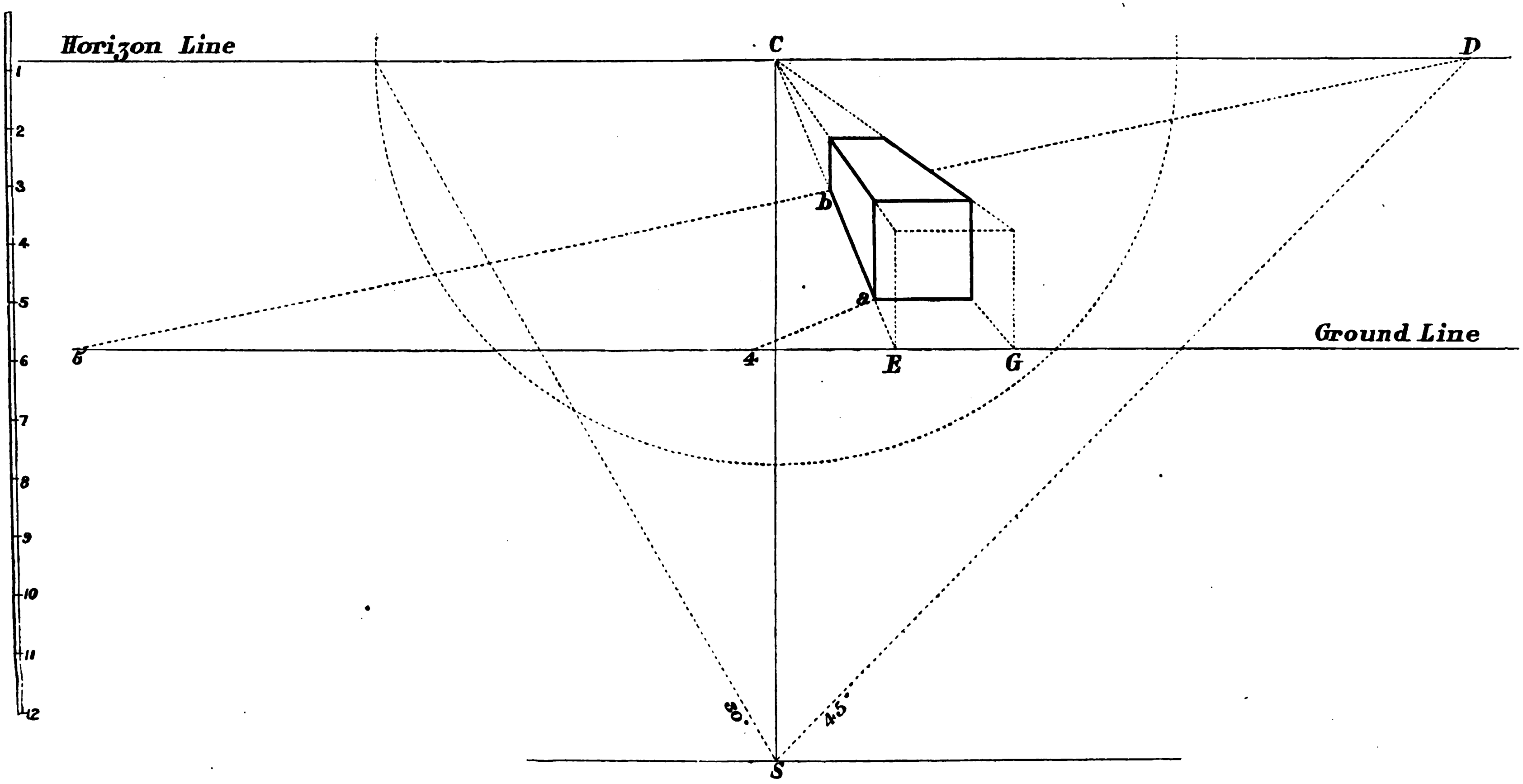
2. A cube of 3 feet side touches the picture-plane with one of its faces, the nearest corner being 2 feet to the left of the centre of vision. Distance 12 feet, height 5 feet.

3. Place the above cube 3 feet into the picture, having its left face 2 feet to the right of the centre of vision.

4. A square board, of 2 feet side, rests on edge with its face parallel to the picture-plane. It is 3 feet from the picture-plane, and the left corner is 1 foot to the right of the centre of vision. Distance 12 feet, and height of the eye 5 feet.

5. Find a point on the ground, 5 feet to the left of the centre of vision, and 8 feet from the picture-plane. In this point place a vertical rod 4 feet high.

6. Find the position of a bird 15 feet right above the top of this rod. Distance 12 feet, and height of the eye 5 feet.


Horizon Line
C
D
b
a
Ground Line
6
4
E
G
30.
45.
S
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2
3
4
5
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8
9
10
11
12

LESSON VIII—Linear Perspective.

The following contractions are henceforth employed:—

C V	stands for	the **centre of vision** or point of sight.
C L V	,,	**central line of vision** or line of direction.
S P	,,	**station-point** or spectator's point.
H L	,,	**horizon-line** or horizontal line.
P L	,,	**picture-line**, the ground-line.
P P	,,	**picture-plane**, transparent-plane, or plane of delineation.
G P	,,	**ground-plane.**
V P	,,	**vanishing-point.**
M P	,,	**measuring-point.**
P D	,,	**point of distance.**

In the exercises, unless where otherwise stated, the distance of the station-point from the picture-plane is 12 feet, and the height of the eye above the ground 5 feet.

The outside measurement of the trough on the plate is 3 feet long, 2 feet wide, and 1 foot deep. The thickness is 6 inches. The end is parallel to, and 1 foot from the *P P*, and the nearest corner is 2 feet to the left of the *C V*.

First. Place the trough in its proper position as a solid block, like the log of wood in Lesson VII.

Second. 1 to 5 is the width of the trough on the *P L*. Make 1, 2, and 4, 5, each equal to 6 inches. From 4 and 2 draw lines towards *C*, till they meet the lower edge of the end of the trough; and from the points of intersection raise vertical lines till they meet the upper edge. From the points found on the upper edge, draw lines to *C* along the top of the block. These lines give the thickness of the two sides. Observe that all the lines drawn since commencing at 4 and 2 are in two separate vertical planes.

Third. 5 to 6 is equal to 1 foot, and 6 to 9 is equal to the length of the trough. Make 6 to 7 and 9 to 8 each equal to 6 inches, the thickness of the trough. From 7 and 8 draw lines towards D_2, till they meet the lower edge of the side of the trough. The points found will each be the perspective distance of 6 inches from the ends of the trough. From these points draw vertical lines to the upper edge of the side, and from the points found, on the upper edge, draw lines across the upper surface of the block parallel to the *P L*. Draw the far, left inside corner parallel to the other corners, and the work is finished.

Observe (first) that you have merely split the original block by four vertical planes, two of these being 6 inches from, and parallel to, the sides of the block; and two of them being 6 inches from, and parallel to the ends of the block; and (second) observe how the 6 inches are cut off from the end and side.

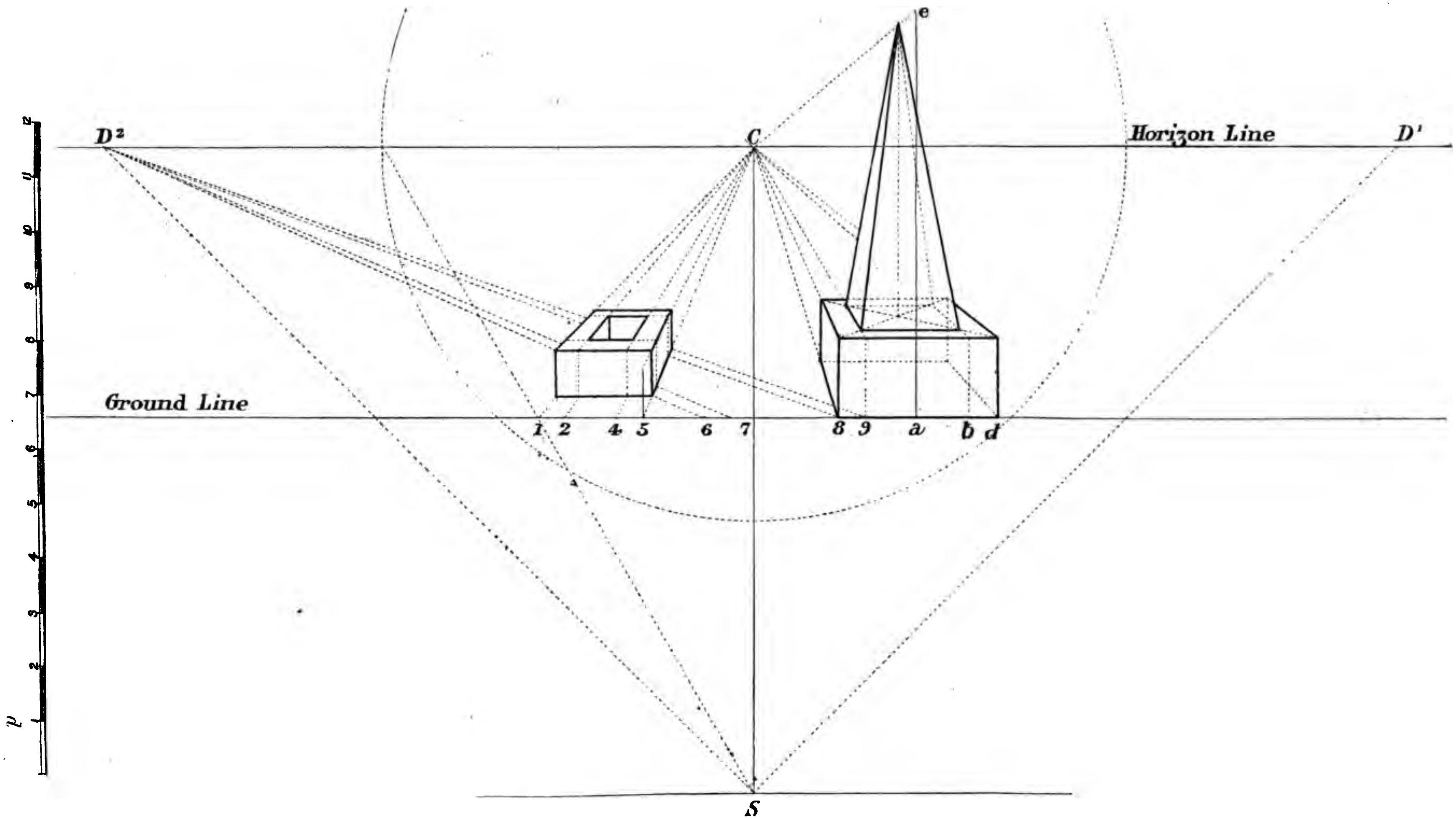
Draw a square block of stone 3 feet side, and $1\frac{1}{2}$ foot thick, touching the *P P* with one of its sides, the left corner being $1\frac{1}{2}$ foot to the right of the *C V*. On the centre of this block place a pyramid 6 feet high, with a square base of 2 feet side, the base lines of the sides of the pyramid being parallel to, and equidistant from the sides of the block.

First. Draw the block having the near corner at the point 8, which is $1\frac{1}{2}$ foot to the right of the *C V*.

Second. Having completed the block, draw diagonals on its upper face. Their point of intersection is the perspective centre of the upper face of the block. From the corners 8 and *d* measure 6 inches to 9 and *b*. From 9 and *b* draw vertical lines to meet the upper front edge, and from the points found on this edge draw lines to *C*. The points where these lines cut the diagonals are the corners at the base of the pyramid.

Third. The top of the pyramid is now required. Bisect 8 *d* in *a*. Draw *a*, *e* perpendicular to the *P L*, and equal to the height of the pyramid from the ground, namely $7\frac{1}{2}$ feet. Join *e C*, and from the intersection of the diagonals erect a vertical line, till it meets the line *e C*. This gives the top of the pyramid, which being joined to the corners at the base, completes the drawing.

Observe (first) how the position of the base of the pyramid is found, and (second) how the height of the pyramid is found. The line *a e* is to be regarded as an edge view on the *P P* of a vertical plane, $7\frac{1}{2}$ feet high, which extends onwards to *C*, its upper edge being *e C*, and its lower edge, a line on the ground-plane, extending from *a* to *C*.


e
D²
C
Horizon Line
D'
Ground Line
a
b
d
S
p

Lesson VIII. continued.—Linear Perspective.

Exercises.

1. Place the block and pyramid of this lesson with the right corner of the block 2 feet to the left of the *C V*, and 1 foot from the *P P*.

2. Find a point on the ground-plane 4 feet to the right of the *C V* and 7 feet from the *P P*. Let this point be the corner of a square pillar of 2 feet side and 8 feet high, one side being parallel to the *P P*.

3. A rectangular block, $4\frac{1}{2}$ feet long, 3 feet wide, and 2 feet thick, has its near end 2 feet from, and parallel to the *P P*, and its left side 2 feet to the right of the *C V*.

4. Place the block so as to have its side parallel to the *P P*, and 3 feet distant from it, while the right end is 2 feet to the left of the *C V*.

5. Find a point on the ground-plane 2 feet to the right, and 6 feet from the *P P*. Let this be the centre of the base of a pyramid, 7 feet high and 3 feet side at the base, which is a square, with two sides parallel to the *P P*.

6. Find the position on the ground-plane of 6 points, 2 feet apart, each being 8 feet from the *P P*. The leftmost point is directly in front.

7. At each of these points place a vertical rod, each rod being 1 foot higher than the one to the right of it. Make the smallest rod 2 feet high.

8. Suppose the trough of this lesson is turned on its side so that the inside may be seen, the end being 1 foot from and parallel to the *P P*, and its nearest corner 4 feet to the left of the *C V*. Draw it.

Note.—Two of the vertical planes to which attention was directed in the lesson will become horizontal planes in this exercise. To represent the inside bottom of the trough, which will be visible, another vertical plane will be required. The bottom of the trough is not seen in the plate.

10. The trough is placed on its end, so that the inside may be seen, the side being parallel to the *P P*, and the nearest corner 5 feet to the right of the *C V*, and 2 feet from the *P P*. Draw it.

11. Sink the trough, so that the top edges may be level with the ground. Let its position be that which it occupies in the plate of this lesson.

Note.—In this drawing the inside bottom of the trough will be visible. Its position is 6 inches below the level of the ground, and may be found, by measuring 6 inches below the ground-line, and drawing through it a horizontal line. This horizontal line is an edge view of the plane in which the horizontal lines at the bottom of the trough lie.

12. A pyramid, with square base of 2 feet side, is 5 feet high, and stands on a block of 3 feet side and $1\frac{1}{2}$ foot high. Draw the block and pyramid, supposing the top of the pyramid to be 2 feet to the right of the *C V* and 4 feet from the *P P*. One face of the block is parallel to the *P P*.

13. Show the line of intersection of two vertical planes, one being at right angles to the *P P*, and 3 feet to the right of the *C V*, and the other being parallel to the *P P*, and 6 feet into the picture, supposing the planes are 4 feet high.

Questions.

1. How do you find the points of distance? 2. What is the use of the points of distance? 3. What lines have no vanishing-point? 4. What lines vanish to the *C V?* 5. What lines vanish to the *P D?* 6. Of what lines is the *C V* a measuring-point? 7. Of what lines is the *P D* the measuring-point? 8. Explain what a measuring-point is. 9. Describe how you transfer vertical measurements from the *P P* to any object into the picture. 10. What is meant by "into the picture"? 11. Describe how you transfer a horizontal measurement from the *P P* to any object into the picture.

LESSON IX.—Model Drawing.

LAY on the table a quarto volume, on its side, straight in front of you, and four or five feet off, with its end towards you. In this position only one end and the upper board will be seen.

For the purpose wanted, a box or other rectangular object will do equally well as a model, provided it be so placed that the top and the near end only can be seen. A quarto volume is here selected as likely to be readily accessible to every one for home practice.

First. Draw the near end any size you please, but the larger the better, taking care to have the thickness in correct proportion to its width. To find whether you have obtained this proportion correctly, as shown in last lesson on model drawing, take a *pencil measurement* as follows. Hold out the pencil upright at arm's length, and take the measure of the thickness of the book between the end of the pencil and the thumb-nail. With this measure turn the pencil round, keeping it still at right angles to the central line of vision, and observe how often this size is contained in the width of the book; that is, observe the proportion which it bears to the width. What you have sketched on your paper should be in the same proportion.

Second. Stretch out a cord horizontally, level with the eye, and at right angles to the line of vision. This line of the cord transferred to the background is the horizon (or sight) line. Note on the line on the background the point directly opposite the eye. This point is the centre of vision. By pencil measurement at arm's length, find how high this point is above the book, by taking the width (or thickness) of the book as before, and finding how often this size is contained in the vertical height from the book to the centre of vision. Next take the corresponding width (or thickness) in the drawing, and measure it the same number of times straight upwards on the paper from the drawing. The point found may be off the paper, but wherever it may be, it is the centre of vision on your picture-plane, through which draw the horizon-line. Suppose it is on the table and not on the paper; then keep the paper fixed in position, and from the corners of the sketch draw lines towards the *C V*. The retiring lines of the sides of the book have now been found.

Third. Draw the far edge of the book. In order to do this correctly, compare by pencil measurement the thickness (or the width) of the book, with its foreshortened length. Through the point found, draw a line parallel to the near edge, and the drawing is completed.

Fourth. Should the real length of the book be known, its perspective length may be obtained by means of the points of distance, as in the exercises in linear perspective. But the distance of the station-point—that is, the position of the eye—from your picture-plane would first require to be found, and this is obtained as follows. Take the measure of one of the lines on your drawing, between the pencil-end and the thumb-nail. Move this measure forward at right angles to the central line of vision, between the eye and the book, until it exactly covers the corresponding line on the book. The point where this happens is the distance of the picture-plane from the station point. Measure this distance from the centre of vision on your drawing, along the horizon-line, and the point of distance wanted is found.

For further practice, place the book a foot or so to the left and sketch it, then a foot to the right, and do the same. Set it up on end in front, next to the right, then to the left. Lay it down with the back towards you, and draw it again in different positions, always (in the meantime) taking care to keep one edge of it parallel to the central line of vision. Afterwards take a number of books, and proceed with them in a similar manner.

General Directions.

1. Always draw on as large a scale as possible while practising model drawing.

2. In order to keep the pencil at a *constant* distance from the eye, always hold it at arm's length, while taking a pencil measurement.

3 In taking a pencil measurement it is absolutely necessary to hold the pencil at right angles to the line of vision; and great care must be taken to hold the head in exactly the same position, as any alteration in this position makes an alteration of the station-point.

4. To obtain the correct angle which any two lines may have in perspective, fold a slip of paper between the eye and the object so that the *fold* and *edge* of the slip may coincide with the two lines, the plane of the paper thus folded being kept at right angles to the line of vision. The angle thus obtained may then be readily transferred to the drawing.

5. Bear always in mind the law that governs parallel lines.

LESSON X.—Linear Perspective.

WHEN a curved line requires to be drawn in perspective, a number of points must be taken in the curve, and their position on the picture-plane found. The curve is then drawn with the hand through these points.

Draw in perspective a circle on the ground, 4 feet diameter, which touches the picture-plane, 3 feet to the left of the centre of vision.

Measure 3 feet to the left of the centre of vision, which will give the point of contact o. From o draw a vertical line downwards, and from any centre on this line describe a circle 4 feet diameter. Inclose this circle in a square, and divide the figure as in the plate. This gives eight points in the circle, the position of which requires to be found in perspective.

Draw the square in perspective. Divide the square thus drawn as it is divided in the plan, and the eight points are found. Through these points draw the curve with the hand, and the drawing is completed.

The figure on the right represents the same circle placed in perspective, 5 feet to the right of the centre of vision, at right angles to the picture-plane and the ground-plane, and touching both.

The plan may be placed anywhere on the paper, and it is not necessary to draw a plan of the entire circle as here. A semicircle enclosed in a rectangle would have done quite as well, since the divisions on the two halves of the circle are alike.

Any curve may be drawn in perspective in a similar manner. You take a number of points in the curve, and obtain the true relation of these points to the sides of some rectangular figure, so that when the perspective representation of the rectangular figure is found, the points in the curve may be found also. In other words, you place in perspective a certain number of points in the curve, by means of their *direct* and *lateral* distances; their direct distance being their distance from the picture-plane, their lateral distance being their distance to the right or left of the central line of vision. The direct distance of a point is a distance measured either on the central line of vision or on a line parallel to it. The lateral distance of a point is a distance measured on a line at right angles to the central line of vision.

Exercises.

1. Draw in perspective a circle of 5 feet diameter, which lies on the ground, the centre being directly in front and 4 feet from the *P P*.

2. Place another circle directly over the one in last exercise, so as to form a cylinder 3 feet high by 5 feet diameter.

NOTE.—To do this, a line must be drawn 3 feet above the *P L* and parallel to it, as a base line, to represent an edge view of the plane in which the upper circle lies. This line is used in drawing the upper circle, precisely in the same manner as the *P L* is used for the circle on the ground.

3. A circle of 4 feet diameter lies in a horizontal plane, on a level with the eye. The centre is directly in front, and 4 feet into the picture.

4. Represent the circle in the last exercise, when raised 4 feet above the height of the eye.

5. Place the same circle on the ground, at the same distance from the *P P*, but removed 3 feet to the right of the *C V*.

6. Draw a circular slab, $3\frac{1}{2}$ feet in diameter, and 1 foot thick, which lies on the ground-plane, its centre being 4 feet to the left of the *C V*, and 5 feet into the picture.

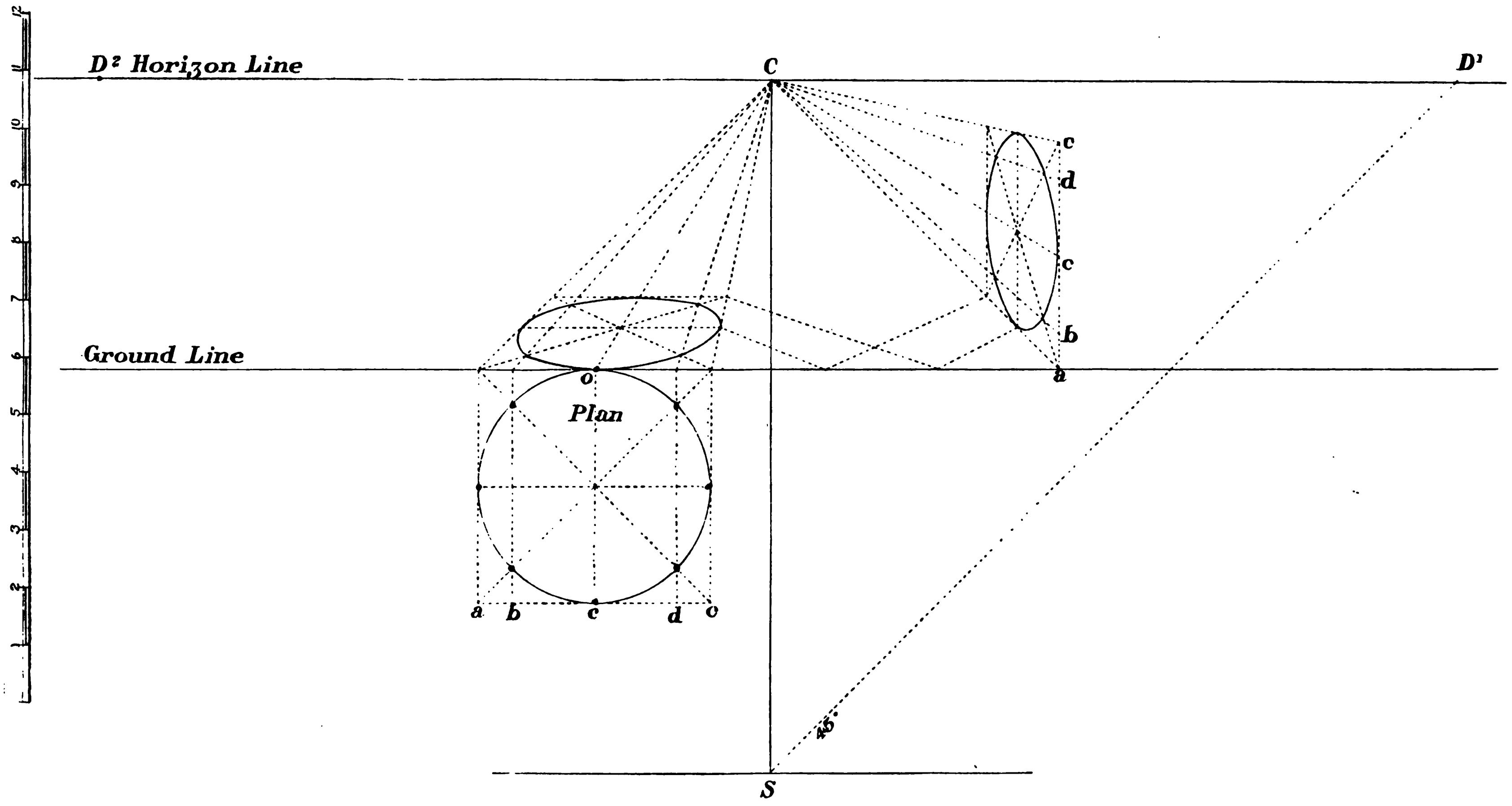
7. Place the slab so as to have the two circular faces at right angles to, and touching both the *G P* and the *P P*, the nearest face being 3 feet to the right of the *C V*.

8. Represent a cone, 4 feet diameter at the base, and 6 feet high, its centre being $2\frac{1}{2}$ feet from the *P P*, and 3 feet to the right of the *C V*.

9. Suppose this cone removed 3 feet to the left, and cut across horizontally at 2 feet from the ground. Draw this frustum.

NOTE.—The plan of the frustum must first be drawn.

10. A wall, parallel to the *C L V*, is 18 feet long, 9 feet high, and 2 feet thick. In the centre of the wall there is an archway, 4 feet wide and 5 feet high to the spring of the semicircular arch. The end of the wall touches the *P P*, at a point 5 feet to the right of the *C V*.


D² Horizon Line
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LESSON XI.—Linear Perspective.

THE example in the plate represents the interior of a room 16 feet long, 13 feet wide, and 12 feet high, as seen 18 feet distant from the near end, and 1 foot to the left of its centre, on the supposition that the near end wall is taken away.

The height of the eye is 5 feet, and the *PP* is supposed to occupy the position of the inner surface of the wall, which is taken away. There are two windows in each side wall, 7 feet high and 3 feet wide, and 2½ feet from the floor. These are 4 feet apart, and each is 3 feet from the end of the room. A door 7 feet high and 3 feet wide is in the end, and 1 foot from the right side wall. A pendant, 5 feet long, hangs from the centre of the ceiling, and has two arms, each 1½ foot long. The thickness of the side walls is 1 foot, and that of the end wall 1½ foot.

The lines which bound the walls, floor, and ceiling, are first drawn in their proper relation to the *CLV*, and the *PP*. Then lay off on the *PL* by scale, as shown in previous exercises, the actual length of the side of the room, marking off the divisions of windows, at *a*, *b*, *c*, *d*. For the perspective width of the windows on the left, draw lines from *a*, *b*, *c*, *d*, to D^1. Where they meet the line drawn from *e* to *CV*, will be the points required. Transfer these widths with T square to the opposite wall, to the line from *d* to *CV*, for the widths there, of the windows which are directly opposite. For the height of the windows, make on the *PP*, the line $df = 2\frac{1}{2}$ feet, and $fg = 7$ feet; and from these points draw lines to *CV*. The remaining details of the drawing are drawn on the same principle, namely, by measuring all sizes on some vertical or horizontal line on the *PP*, and transferring these into the picture, either on a vertical or horizontal plane, according as these measurements are vertical or horizontal.

Observe, first, how the thickness of the wall is shown at the windows on the right; by drawing lines from *f* and *h* to *CV*. Second, observe how the width and height of the door are obtained, also the thickness of the end wall at the door. The latter is found by drawing a line from 17½ to D^2, and where it cuts the line from *J* is the point found. The distance from the *PP* to the outside of the end wall is 17½ feet (16 + 1½) and is measured from *J* to the left. Third, observe how the pendant with the two arms is found, by drawing a vertical line of 5 feet, from *K* on the *PP*, and constructing the length of the arms on it.

Exercises.

1. Draw the interior of the room given in the example, supposing the *SP* to be 18 feet from the *PP*, and 3 feet to the right of the centre of the room. Let the door be removed to 1 foot from the left side wall.

2. Instead of windows, suppose there is an opening, 7 feet 6 inches high, and 4 feet wide, in each side wall, over each of which is thrown a semicircular arch, the *SP* being 18 feet distant, as in the last exercise, but directly opposite the centre of the room.

3. Draw in perspective an equilateral triangle of 5 feet side, on the ground; one side being at right angles to, and touching, the *PP*, and 3 feet to the left of the *CV*.

NOTE.—This exercise, and some of the following, may be done by first inclosing the figure in a square or rectangle.

4. Draw in perspective a pentagon on the ground, of 4 feet side, one side being parallel to the *PP*, and 1 foot from it. The *SP* is directly opposite the centre of the pentagon.

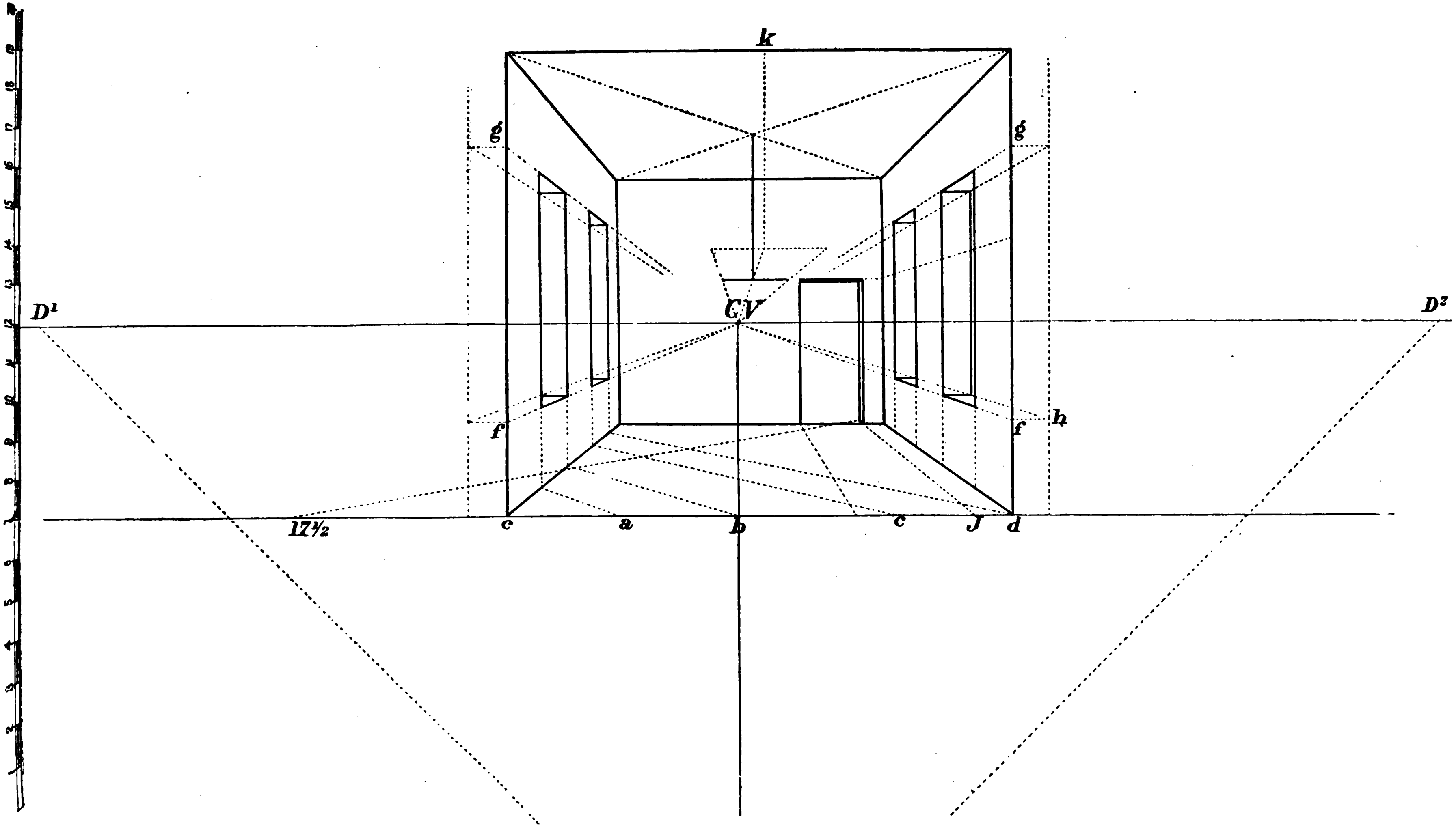
5. Draw in perspective a hexagon on the ground, of 2 feet side; one side being parallel to, and 2 feet distant from, the *PP*. The centre of the hexagon is 4 feet to the right of the *CV*.

6. Construct the last exercise into a hexagonal prism 4 feet high.

7. Represent in perspective this prism, when lying on one of its faces, with its axis at right angles to the *PP*. The end of the prism touches the *PP*, and the axis is 6 feet to the left of the *CV*. Distance 18 feet.

Questions.

1. When are parallel lines represented by converging lines? 2. When are parallel lines represented by parallel lines? 3. What is a vertical plane? 4. What do you mean by saying that a line is in a plane parallel to the ground? 5. In what position must a circle be placed to appear a horizontal line. 6. How must it be placed to appear perfectly round? 7. In what position will a line appear a point? 8. In what position will a line appear longest? 9. In what position will a horizontal plane appear a horizontal line? 10. In what position will a vertical plane appear a horizontal line? 11. In what position will a vertical plane appear a vertical line? 12. Give a rule for drawing lines which lie at right angles to the *PP*.


k
g
g
CV
D¹
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LESSON XII.—Linear Perspective.

In this lesson you begin to draw in perspective objects having lines which make oblique angles with the *P P*. This is called oblique perspective. The use of the plate is to show how the vanishing-point and the measuring-point of *any* horizontal line may be obtained.

The line *A B* through *S* is drawn parallel to *P L* or *H L*, and hence any line drawn from *S* will make the same angle with *P L* or *H L* as it makes with *A B* (Euc. I., 29). That is, it will make the same angle with the *P P* as it makes with *A B*.

Required the *V P* of a horizontal line which makes an angle of 40 degrees with the *P P* towards the left. From *S* draw a line at 40 degrees to *A B*, meeting the *H L* in VP^1. This is the point required.

Required the measuring-point of any line which has VP^1 as its vanishing-point, that is, any line which makes towards the left, 40 degrees with the *P P*. From VP^1 as a centre, and with the distance to *S* as radius, describe an arc cutting *H L* in MP^1. This is the point required. Were the circle completed, the point where it cuts the *H L* on the other side of VP^1 would be the other *M P*. This *M P* is not shown on the plate. In practice one *M P* is sufficient. It will be observed that the principle on which the points of distance and the measuring-points are found are the same. In both cases you take the *V P* of the line whose *M P* is wanted as centre, and the distance from the *V P* to the *S P* as radius.

The line *E D* on the plate is so drawn as to have VP^1 as its *V P*; it is required to find on *E D* a point 5 feet from *D*. From *D* measure on *P L* 5 feet to *F*. From *F* draw a line to the measuring-point (MP^1), cutting *E D* in *G*. The point *G* is, in perspective, 5 feet from *D*. In the same manner any distance may be measured on the line *E D*, or on any vanishing-line when its measuring-point has been determined.

Exercises.

1. Find the *V P* and *M P* of horizontal lines which lie at an angle towards the right of 47 degrees to the *P P*.

2. From a point on the *P L*, 2 feet to the left of the *C L V*, draw a line to the *V P* found in the last exercise, and on it find a point 6 feet from the near end of the line.

3. Find the *V P* and *M P* of horizontal lines which lie at an angle towards the left of 38 degrees to *P P*.

4. From a point on *P L*, 2 feet to the left of *C L V*, draw a line to the *V P* found in last exercise; and on this line find three points, at 3, 6, and 9 feet distant respectively from the near end of the line.

5. A straight rod, 6 feet long, lies on the ground, and touches the *P P* at 4 feet to the right of the *C L V*, and makes an angle towards the left of 50 degrees with the *P P*. Draw the rod.

6. The end of the rod touches the *P P*, 2 feet to the left of the *C L V*, and makes an angle towards the right of 70 degrees with the *P P*. Draw the rod.

7. A square of 4 feet side lies on the ground-plane, with one corner touching the *P P* at a point 2 feet to the right of the *C V*. The sides to the right lie at 50 degrees to the *P P*, and consequently those to the left lie at 40 degrees to the *P P*. Draw the square.

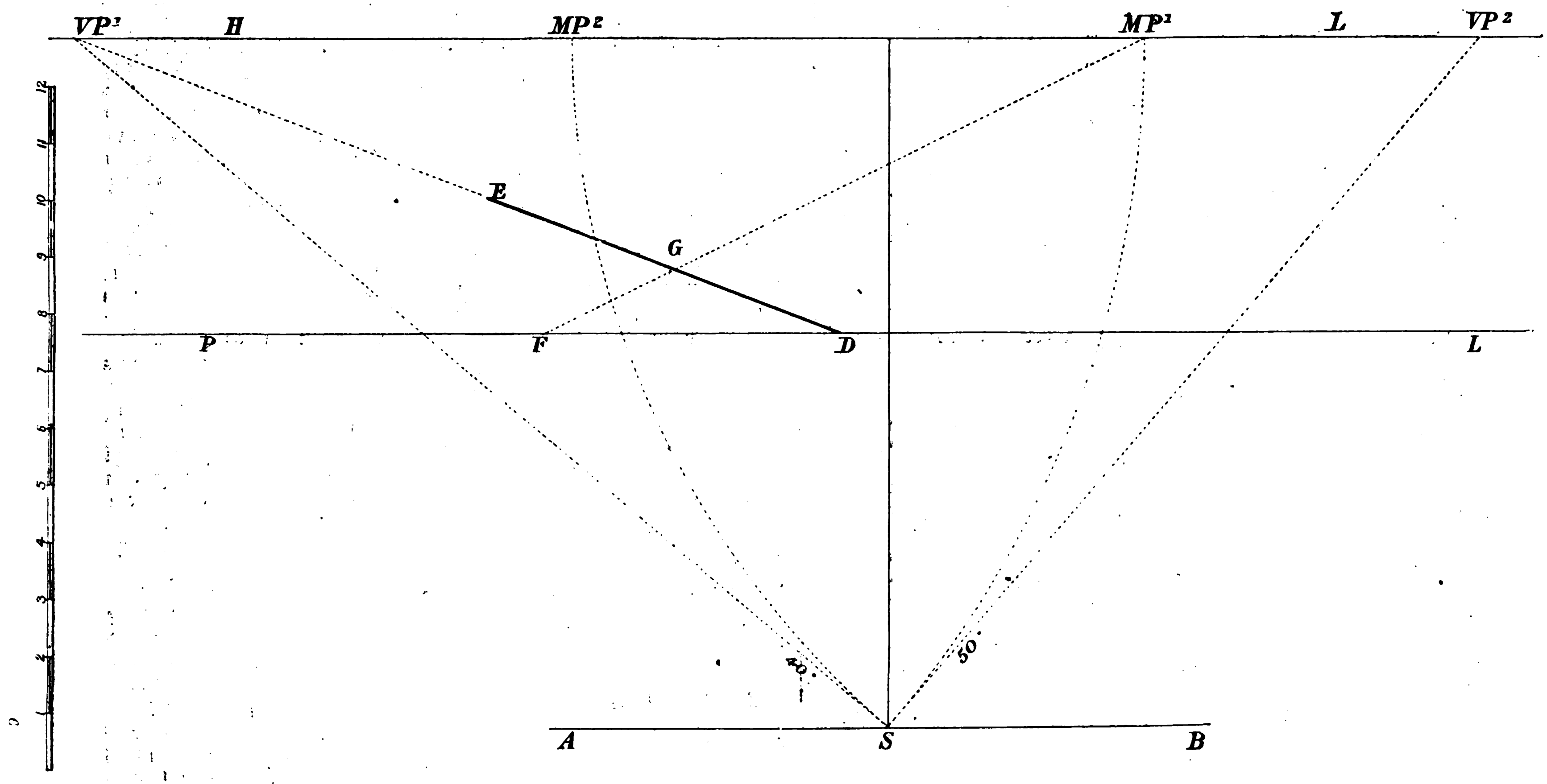
8. Construct a cube on the square of last exercise.

9. Draw in perspective six upright posts, each 7 feet high and 4 feet apart, standing in a line, which makes an angle towards the left of 60 degrees with the *P P*. The nearest post touches the *P P* 4 feet to the right of the *C V*.

NOTE.—Find the *V P* and *M P*, and at a point on the *P L* 4 feet to the right, erect a vertical line equal to 7 feet. This represents the nearest post. From the top and bottom of this vertical line draw lines to the *V P*. This will represent the vertical plane in which the posts stand. By means of the *M P* find the points where they stand, and from these points erect vertical lines to represent the posts.

Questions.

1. What is a *V P*? 2. What is an *M P*? 3. What is the *M P* of the lines which vanish in the *C V*? 4. What is the *V P* of the diagonal of a square lying on a horizontal plane, and having two of its sides, parallel to the *P P*? 5. What is the *V P* of lines which are at right angles to the *P P*? 6. What is the *V P* of horizontal lines which lie at 45 degrees to the *P P*? 7. How do you find the *V P* of a given horizontal line? 8. How do you find the *M P* of a given horizontal line? 9. How do you find the distance into the picture of a given point on the *G P*? 10. How do you find the distance into the picture of a given point lying in a plane above the *G P*? 11. Is the centre of vision the centre of the picture?


VP¹
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MP²
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LESSON XIII.—Linear Perspective.

THE example on the plate represents a block, 8 feet long, 4 feet wide, and 2 feet thick, lying on the ground. The nearest corner is 2 feet to the left of the $C L V$, and 2 feet into the picture. Its sides lie at 40 degrees, and its ends at 50 degrees to the $P P$.

The $V P$ and $M P$ of the horizontal lines of its sides are first found. They are $V P^1$ and $M P^1$. Next the $V P$ and $M P$ of the horizontal lines of its ends are found. They are $V P^2$ and $M P^2$. One, at least, of the points of distance should also be marked on the $H L$. Both are here marked in D^1 and D^2.

First on the $P L$, measure 2 feet to the left of the $C L V$ as in d. Join d, C. On $d C$ find the point o, which is 2 feet into the picture. This point is the nearest corner of the block on the ground.

Second. At d, erect a vertical line on the $P L$ and make it equal to the thickness of the block. Join the top of this line, and C. These two lines, drawn to C, are the top and bottom edges of a vertical plane, 2 feet high, and 2 feet to the left, and vanishing to C. From o erect a vertical line, till it meets the line drawn to C. This line represents the near upright edge of the block. From the top and bottom of this edge, draw lines to $V P^1$, for the side lines of the block; and also to $V P^2$ for the end lines of the block.

Third. To find the measurement of the side of the block. From $M P^1$ draw a line through o to meet the $P L$ in f. Make $f g = 8$ feet, and from g draw a line towards $M P^1$. The point where this line meets the vanishing-line from o to $V P^1$ is the corner of the block on the ground. From this point, erect a vertical line to meet the upper edge of the side; and from the point so found draw a line to $V P^2$.

Fourth. To find the measurement of the end of the block. From $M P^2$ draw a line through o, to meet the $P L$ in b, make $b a = 4$ feet. From a, draw a line to $M P^2$. The point where it meets the line from o to $V P^2$ gives the width on the ground, of the end of the block. From this point erect a vertical line to meet the upper edge of the end, and from the point found draw a line to $V P^1$, which completes the drawing.

It is important to observe how the points f and b are found, from which the measurements are laid off on the $P L$ in order to obtain the perspective lengths of the side and end of the block.

Suppose now that the block is given drawn in perspective, as in the plate, together with the $C V$, the $P L$ and the $S P$, and it is required to find the real size of the block.

You reverse the foregoing process as follows. Produce the side and end lines of the block to find $V P^1$ and $V P^2$, and from these points draw lines to the $S P$; which at that point will form a right angle. Find $M P^1$ and $M P^2$, as shown above. Should the $S P$ not be given, it may be found thus. Bisect the distance from $V P^1$ to $V P^2$, and from the point of bisection as centre, and half the distance as radius, cut the $C L V$ in the $S P$. (Euc. III. 31).

First. From C, draw lines through the top and bottom of the near upright corner at o, and produce the lower one to the $P L$ in d. Erect a vertical line from d, to meet the upper line from C. This vertical line represents to scale the real thickness of the block.

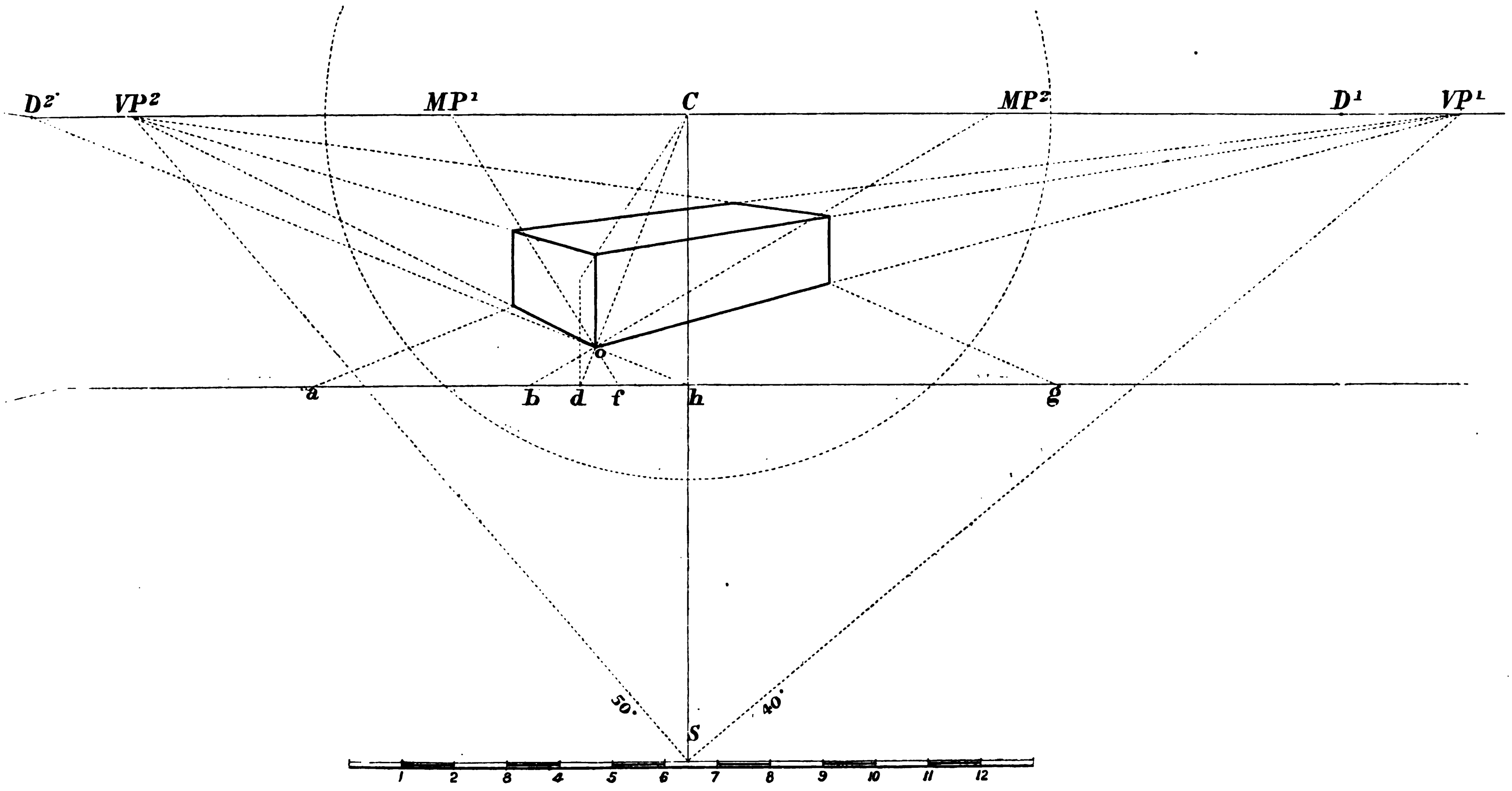
Second. From $M P^1$, draw lines through o, and the other end of the long edge on the ground, till they meet the $P L$ in f and g. The line $f g$ is the length of the block to scale.

Third. From $M P^2$, draw lines through o and the corner of the block on the ground to the left of o, till they meet the $P L$ in a and b. The line $a b$ is the width of the block.

Fourth. To find how far the point o is from the $P P$. From D^2 draw a line through o, till it meets the $P L$ in h. The line $d h$, is the measure of the distance from the $P P$ into o. The distance of any point into the picture may be found in the same manner. If the point does not lie in the ground-plane, then a horizontal line must be drawn parallel to the $P L$, to represent an edge view of the plane, in which the point lies. The height of this line above the $P L$ must be equal to the height above the ground, of the point of which the distance is required. In other words, the horizontal-plane in which the point lies is supposed to be produced, till it intersects the $P P$ in the horizontal line mentioned. This base-line is then used precisely like the $P L$.

Questions.

1. How do you find the distance into the picture of a given point lying in a plane below the $G P$? 2. When it is said that a point lies in a plane 2 feet above the ground, what is meant? 3. How would you represent such a plane on your drawing? 4. On what are horizontal distances measured, which are on the level of the ground? 5. On what are horizontal distances measured, which are 2 feet above the ground? 6. How do you find the real length of any given line on the picture, when the line lies on the ground parallel to the $P P$?


D²
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Lesson XIII. continued.—Linear Perspective.

Exercises.

1. Suppose the block in the last plate is so placed as to have its nearest corner 3 feet to the right of the *C L V*, and 2 feet from the *P P*, and the long edges lying towards the left at an angle of 38 degrees to the *P P*, draw it, and find how far the farthest corner is removed into the picture.

2. Place a square slab of 4 feet side, and 1 foot thick, on the upper face of the block of the last exercise, so as to have its centre right above the centre, and its edges parallel to the edges, of the block.

3. A log of wood 10 feet long, with a square end of 2 feet side, rests on two cubes of 2 feet side, which are placed 1 foot from either end of the log. The log lies towards the right, at 40 degrees to the *P P*, and touches the *P P*, 3 feet to the left. The sides of the cubes are parallel to the sides of the log.

4. A triangular prism, 7 feet long and 3 feet wide, lies on the ground on one of its long faces, at an angle of 45 degrees to the left. The nearest corner is 3 feet to the right of the *C L V*, and 3 feet from the *P P*.

Note.—In order to obtain the vertical height of the prism, draw an elevation of the equilateral triangular end.

5. Find the distance from the *P P*, of the farthest point of the prism in last exercise.

6. Suppose the triangular prism stands on the ground, on its end, having two sides of the base at equal angles to the *P P*, and the other parallel to it. Draw the prism, having the near corner of the base touching the *P P*, and 3 feet to the right of the *C L V*.

7. Keep the prism in the same relative position to the *P P*, but let the nearest corner of the base be 3 feet to the left, and 1 foot into the picture.

Find a point (*A*), 2 feet to the left of the *C L V* and 1 foot within the *P P*, and another point (*B*), 1 foot to the right of the *C L V* and 6 feet within the *P P*. Let the line *A B* be the base of an equilateral triangle, which lies on the ground; the nearest point of the triangle being 1 foot from the *P P*. Draw the triangle in perspective.

Note.—After finding the points *A* and *B*, it will be necessary to find the real distance between them, in order to get a plan of the triangle, preparatory to drawing it in perspective.

LESSON XIV.—Linear Perspective.

In the foregoing lessons and exercises the objects chosen for the purpose of illustration or practice do not vary in size to any great extent, while the vertical plane on which they are to be drawn is supposed to stand at a distance of 12 feet from the station-point, the height of the eye above the ground being 5 feet. It is obvious, however, that actually to draw any of these objects on such a plane is impracticable; since, to do so, would require a sheet of paper of enormous size. This apparent difficulty has been overcome by drawing to a reduced scale, and the scale has hitherto been left to the choice of the student. By adopting a scale of 1 inch, $\frac{3}{4}$ inch, or $\frac{1}{2}$ inch to a foot, the drawing is brought within the limits of an ordinary sheet of paper. But consider what the use of a scale effects. It enables you to do more than merely produce a reduced copy of this large plane 12 feet distant, with the drawing of the object on it. You have actually made a drawing on a vertical plane—the plane of your paper—which when interposed between the eye and the object, would intercept, at a few inches from the eye, the several rays that may be supposed to come from the object to the eye. This distance from the eye at which the drawing should be placed when looked at, is determined by the scale which has been adopted. If the scale is 1 inch to a foot, or $\frac{1}{12}$, the distance of the plane is 1 foot, or $\frac{1}{12}$ of the whole distance. If the scale is $\frac{1}{2}$ inch to a foot, or $\frac{1}{24}$, the distance of the plane is 6 inches, or $\frac{1}{24}$ of the whole distance. In other words, the drawing is meant to be looked at from a distance of 6 inches, 9 inches, a foot, or a yard, according to the scale on which it has been constructed.

If, on the other hand, you required to make a drawing of an object 100 yards distant, on a picture plane 1 yard distant; that is, on a picture which was intended to be looked at from the distance of a yard; this distance would determine the scale of the drawing as well as set limits to the size of the picture. In this case the scale would be $\frac{1}{100}$ of the real size of the object. It follows, therefore, that the distance of the picture determines the scale, and when the scale is given, this determines the distance of the picture.—See General Principle 10, Lesson VII.

LESSON XV.—Model Drawing.

PLACE a thick quarto volume, or rectangular box, flat on the table, four or five feet away from you, and so as to have two of its edges at (say) from 30 degrees to 50 degrees to the *P P*.

First. Draw a vertical line to represent the near upright edge of the model. Determine the *C V* and the *H L* on your paper, or *off* it, as it may happen to fall, according to the directions given in Lesson IX.

Second. Find the vanishing-point of the parallel horizontal lines of the model, that incline to the right. To do this look in a direction parallel to these lines, and where the eye catches the horizon-line on the background, there is the point required. Find, by pencil-measurement, how often the near upright edge of the model can be measured from the point found, along the horizon-line, to the centre of vision on the background. Suppose it is six times. Then measure the length of the upright line, which you have drawn on your paper, six times, from the *C V* towards the right, along the *H L*, and the *V P* required on your paper is found. Any other size which you have determined on your drawing, would do equally well as a unit of measurement in finding the *V P*; such as, in this case, the vertical height from the horizon-line, to the top or bottom of the near upright edge of the model.

Another Method. Determine the *S P* for your drawing; that is, the distance from which your drawing is ultimately to be looked at. Lay your paper flat, with the *H L* and the *C L V* in proper position. Bring the edge of a ruler to the *S P*, and have it parallel to the horizontal lines of the model that incline to the right. The point where the edge of the ruler cuts the *H L* is the *V P* required on the plane of your paper.

The *V P* for the lines which incline to the left may be found in a similar manner; but it may be found more easily by drawing a line from the *S P* at right angles to a line joining the *S P* and the *V P* already found; that is, at right angles to the edge of the ruler. This line, which is parallel to the edges of the model, which incline to the left, will cut the *H L* in the *V P* required.

Third. From the top and bottom of the upright line on your paper draw lines towards the *V P* on the right. Compare, by pencil-measurement, the apparent length of the near upright edge of the model, with the apparent length of the foreshortened side of the model on the right. Determine the proportion which the latter bears to the former, and make the corresponding foreshortened side of your drawing bear the same proportion to the upright line. The foreshortened side of the model, that inclines to the left, is determined in a similar manner.

Fourth. From the far top corner of the foreshortened right side draw a line towards the *V P* on the left; and from the corresponding corner of the foreshortened side on the left draw a line towards the *V P* on the right, and the drawing of the model is completed.

If you have not found the *V P* of a foreshortened line which you wish to draw, compare this line on the model with either a horizontal or vertical line, in order that the same test may be applied to the line on your drawing. Should the line on the model approach a vertical line, then bring a vertical line in direct contact with it, between the eye and the object, and observe the inclination of the oblique line. Should the line on the model approach a horizontal line, then bring a horizontal line in direct contact with it. The vertical line in use is a string with a little weight attached. The horizontal line in use is a level or pencil, held at arm's length, horizontally, and at right angles to the *C L V*.

For further practice move a little to the right and sketch the model, then move a little to the left and do the same. Set it up on end, having the sides at any angle to the *C L V*, and draw it. Move to the right and then to the left, and in each position sketch it again. Place the model on the floor, first near you, and then at a distance; next place it above the height of the eye, by means of the model stand, or any other means, and in each position sketch it once or twice. Do this until you are quite able to determine quickly the *C V* and the *V P s* on your paper (or off it), as well as to draw, with a fair degree of accuracy, the object placed in any possible position, when resting flat on one of its surfaces.

Continue the practice on other objects to which the above rules can be applied. Place several volumes on the table, some lying flat, and others on end, and sketch them. Pull out a drawer a few inches and try it from different positions. Open the door of the room half-way and sketch it, with the doorway, and whatever you may see beyond. After having gone through this and similar practice there are many subjects out of doors, such as cottages, plain detached houses, churches, &c., which may be attempted, with the prospect of having them fairly correct in their general features.

LESSON XVI.—Linear Perspective.

THE step of a stair 4 feet wide, is 6 inches rise, and 1 foot tread. Draw 4 steps of the stair, supposing the nearest corner of the lowest step is 3 feet to the left of the *C V*, and 1 foot from the *P P*, and the long edges of the steps lie towards the right at 38 degrees to the *P P*. Scale $\frac{1}{2}$ inch to 1 foot.

Having found the several points on the *H L* necessary for the execution of the problem, proceed as follows.

First. Find the near corner of the step on the ground, and from it draw a line to VP^1, and another to VP^2; also, erect on it a vertical line, to which transfer the perspective depth of the steps, from a measuring line on the *P P* at 3, divided into four equal parts, each being 6 inches to scale. From the points so found draw lines to VP^1.

Second. From MP^1 draw a line through the near ground corner of the stair, till it meets the *P L* in 4. From point 4, towards the left, measure 4 divisions, each equal to 1 foot, for the widths of the ends of the steps. From these points draw lines towards MP^1 till they meet the line on the ground which vanishes to VP^1, and from the points where they meet erect vertical lines. The near corners of all the steps are now found—from which lines are drawn to VP^2 for the long edges of the steps.

Third. From MP^2 draw a line through the near lower corner of the first step till it meets the *P L* in 5. From 5 to 6 measure 4 feet, the width of the step. From 6 draw a line towards MP^2 till it meets the lower line of the front step. From this point erect a vertical line till it meets the upper front line of the near step, and from the point found draw a line to VP^1. Do the same in succession with the other three steps, and the drawing is completed.

Observe that the vertical line erected at the near corner of the front step becomes the line of intersection of two vertical planes; the one plane vanishing to the *C V* and the other to VP^1; and at this line of intersection the measurements on the one plane are transferred to the other. The vertical line at 3, on which the measurements are made to scale, is an edge view, on the *P P* of a vertical plane vanishing towards the *C V*. The other vertical line is an edge view—one foot in from the *P P*—of a vertical plane vanishing towards VP^1.

The far corners of the steps might also be obtained in the following manner. From VP^1 draw a line through the far corner on the ground of the lower step, till it meets the *P L* in 0. From this erect a measuring line for heights, and divide it as at 3. Through these points draw lines towards VP^1. Where these intersect the corresponding lines vanishing towards the right, will be found the upper far edges of the steps. Join the points of intersection by vertical lines, and the drawing is completed.

In the same manner by drawing a line through the near corner on the ground, from VP^1 till it meets the *P L*, and following the same process, the near edges could be found. The lines here referred to are not all shown on the plate.

Questions.

1. Suppose the plane of the top of the third step extended to meet the *P P*; at what distance above the *P L* would the planes intersect? 2. How would this intersection be represented? 3. What would be the most direct method of dividing the front edge of the third step into three equal parts? 4. How do you find the centre point of the top of the lowest step?

Exercises.

1. Find the distance from the *P P* of the far front corner of the second step in the example.

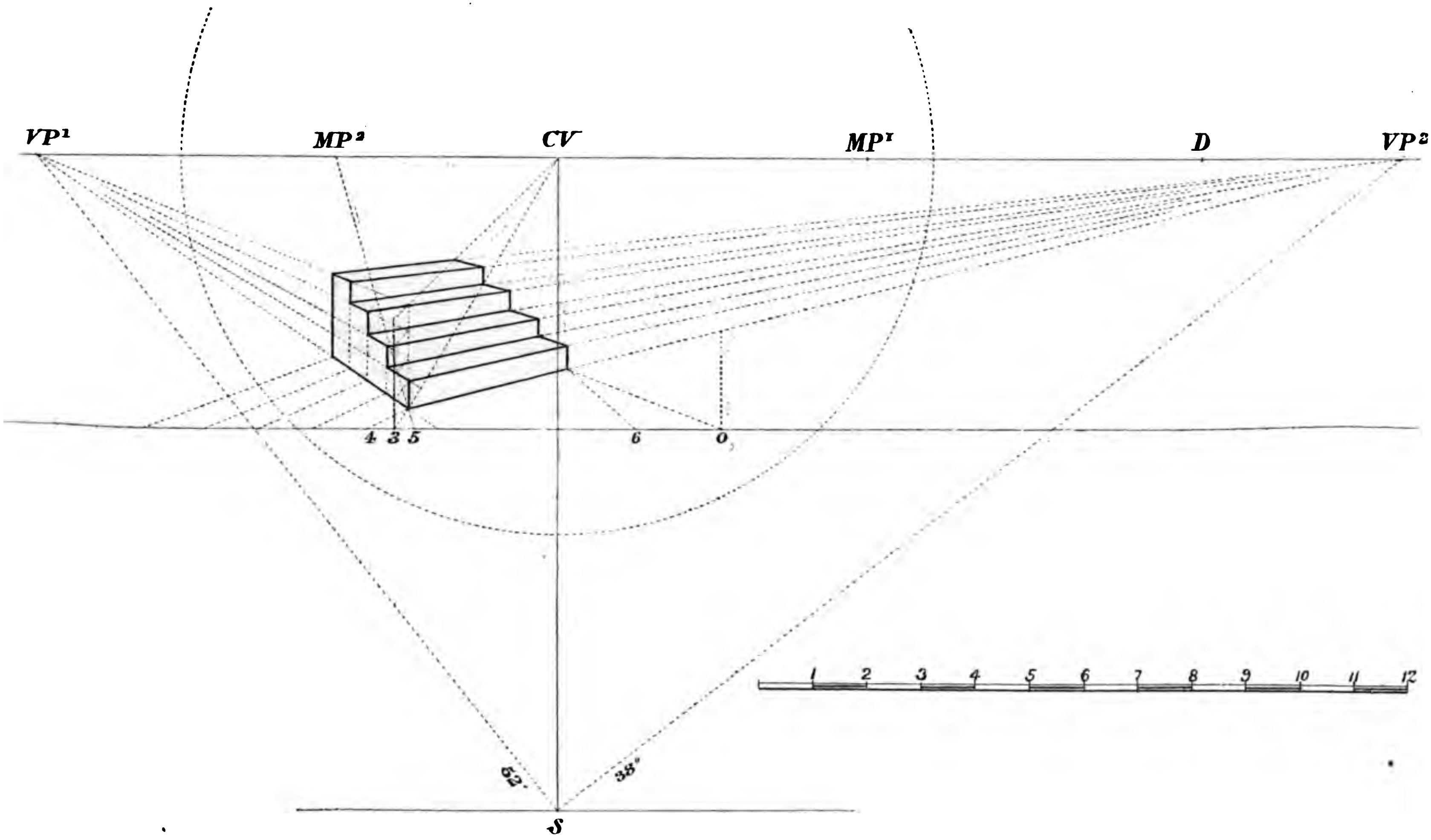
2. Represent a strip of carpet, 2 feet wide, laid on the four steps, the edges of the carpet being 1 foot from either end of the steps.

3. The near end of a line, 8 feet long on the ground, is 2 feet to the right of the *C L V*, and 1 foot from the *P P*, and it inclines to the right at 35 degrees to the *P F*. Make this line the base of a semi-circular arch standing in a vertical plane, and draw the arch in perspective.

4. Represent this arch when laid over on the ground plane into the picture, the base being supposed to remain stationary.

5. A regular octagonal prism, 5 feet long and 1 foot side, lies on one of its faces at an angle of 48 degrees to the right. The nearest corner is 12 feet distant, and 2 feet to the left of the *C L V*. Draw it on a vertical plane 6 inches from the eye.

NOTE.—In order to obtain the proper measurements it will be necessary to draw an elevation of the end of the prism, and since 6 inches is $\frac{1}{24}$ of 12 feet, the drawing must be made to a scale of $\frac{1}{24}$ or $\frac{1}{2}$ inch to 1 foot.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MP²
CV
MP¹
D
VP²
52°
38°
S

LESSON XVII.—Linear Perspective.

A PENTAGONAL pyramid is cut horizontally at 2 feet from the ground; it is required to show the pyramid and section in perspective. The pyramid is 3 feet side at the base, and 6 feet high. One side of the base is parallel to the *P P*, and 2 feet distant from it on the ground, one end of this side being directly in front, and the other towards the left.

First. Draw the pyramid in perspective, under the above conditions. This is most easily done by parallel perspective, as shown. The plate shows two modes of transferring the measurements of the plan, into the perspective drawing. The figure (*F*), on the right, is the plan drawn in its true position, with reference to the ground line, there represented by *X Y*. From the several points on the plan, vertical lines are drawn to *X Y*, and the measurements from 1 to 5, are transferred to the *P L* at 1′2′3′4′5′, and the distances 1 *B*, 2 *C*, 3 *A*, &c., are, by means of the distance-point, cut off from 1′*C V*, 2′*C V*, 3′*C V*, &c. The figure on the left is the plan reversed, and is placed at its true distance from the *P L*, and the several points in it are at their true distances from the *C L V*. The advantage of this method is that the lateral distances of the several points in the plan are transferred at once to the *P L*, by drawing vertical lines, while the distances to which these points are to be carried into the picture can also be transferred at once to the *P L* by describing arcs as shown.

Second. Find the point where the section cuts the centre line of the pyramid. To do this, measure 2 feet up from 3′, on a line of heights, and from the point found draw a line to the *C V*. From *H* through *O* draw a line till it meets the horizon-line in *O′*. From O′ draw a line through the point on the centre line, which is 2 feet from the ground, and produce it till it meets the edge *H* 7. From the point found on *H* 7 draw a horizontal line till it meets *I* 7. Produce *I J*, to find its *V P* in VP^1. This is the *V P* of the corresponding side of the section. From *J* produce the edge of the base at the back to find its *V P* in VP^2. This is the *V P* of the corresponding side of the section. The corner of the section furthest to the left is found, by drawing a horizontal line through the corner farthest to the right.

Were it required to draw the section only in perspective, the easiest method would be, first to find the true size of the section in plan, as well as its distance from the *P P*, and then this pentagon would be drawn in perspective, on a horizontal plane 2 feet from the ground at its proper distance from the *P P* and the *C L V*.

Questions.

1. Explain the principle by which, in this Lesson, 2 feet have been cut off the centre line of the pyramid. 2. Show that the point of the section on *H* 7 is there correctly represented at 2 feet above the ground. 3. Give the reason for each successive step in drawing the section after having found the corner of it on *H* 7.

Exercises.

1. A pyramid of 7 feet high with a square base of 3 feet side, stands on the ground, and has its nearest corner 3 feet to the left of the *C L V* and 2 feet into the picture. Two of the sides of the base incline to the right at 35 degrees to the *P P*. Draw the pyramid in perspective, and also a horizontal section, $2\frac{1}{2}$ feet from the ground. Show also a section of this pyramid when cut through the centre by a vertical plane which lies at 45 degrees to the *P P*. Distance 14 feet, scale $\frac{1}{24}$.

NOTE.—Edge the one section with red, and the other with blue, to secure distinctness.

2. From a point 3 feet to the left of the *C L V* and 1 foot into the picture, draw a line 4 feet long at 37 degrees towards the right. This line is the side of an equilateral triangle, and this triangle is the base of a pyramid 6 feet high. Draw it in perspective and show a horizontal section at two feet above the ground. Distance 12 feet, scale $\frac{1}{24}$.

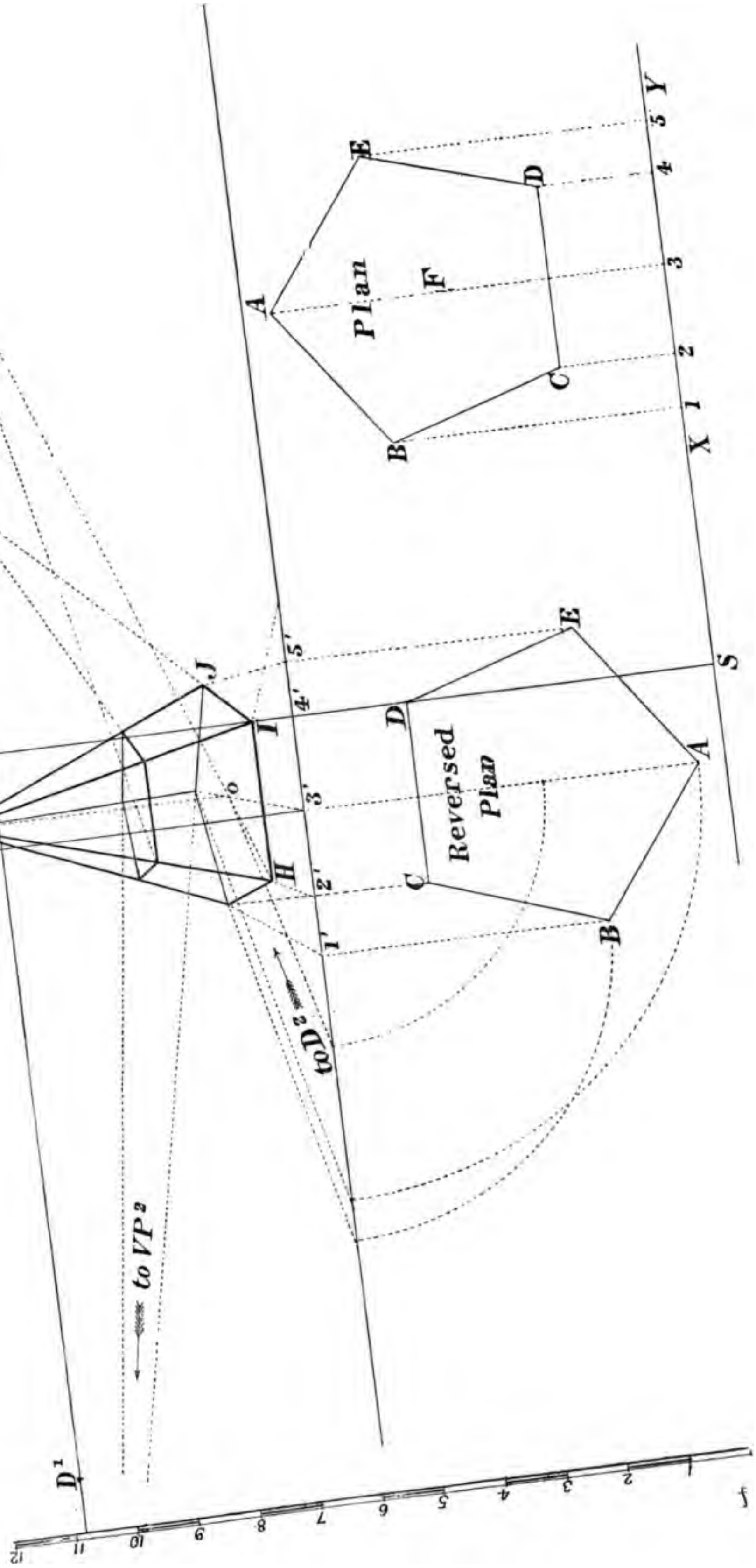
3. A box, $11\frac{1}{2}$ inches long, $7\frac{1}{2}$ inches wide, and $5\frac{1}{2}$ inches deep, stands on a table, the top of which is 1 foot below the level of the eye. The side of the box inclines to the right at 40 degrees to the *P P*, and its nearest corner on the table is 4 feet distant and directly in front. Draw it on a vertical plane 6 inches from the eye.

NOTE.—Since 6 inches is $\frac{1}{8}$ of 4 feet the drawing must be made to a scale of $\frac{1}{8}$ or $1\frac{1}{2}$ inch to 1 foot.

4. Suppose the box is pushed 6 inches towards the left and in a direction parallel to the *P P*. Other conditions being the same, draw it on a vertical plane 8 inches from the eye.

NOTE.—Since 8 inches is $\frac{1}{6}$ of four feet, the drawing must be made to a scale of $\frac{1}{6}$ or 2 inches to 1 foot.

5. The side of the box lies at 40 degrees to the *PP* towards the left, and the farthest upright edge is directly in front. Other conditions being the same, draw it on a vertical plane 8 inches from the eye.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VP¹
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to D²
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LESSON XVIII.—Model Drawing.

A GROUP of models may now be arranged, consisting of two or three rectangular solids. A box, with one or two large volumes, will serve the purpose wanted.

Arrange the models so as to have their horizontal lines at a variety of angles to the *P P*, but without having any of their lines oblique to the *G P*.

First. Determine the size of the sketch, by marking on your paper the highest and lowest points, beyond which your drawing of the group is not to extend. This may be any height you please. Ascertain, by pencil measurement, what proportion the greatest width of the group bears to the greatest height. Then make the width of the space for your drawing bear the same proportion to the height which you have marked on your paper.

Second. Find the *C V* and the *H L*, and in doing so, make the height of the group the unit of measurement on the background, and the height marked on your drawing, the unit of measurement on your paper.

Third. Draw the nearest upright edge of the most prominent object in the group; but before venturing to draw this line, observe its true position to the right or left of the *C V*. Make its height bear the same proportion to the height of the group determined on your paper, which the edge itself bears to the height of the group. Find the *V Ps* of its foreshortened lines, and by pencil measurements complete the drawing of the object.

Fourth. Draw the other objects in a similar manner. In general, draw the larger first, though the order in which it may be best to take them will depend, to a considerable extent, on the grouping. In any case, throughout your entire work, make a constant comparison of any height wanted, with the height of the group, or with some *particular* height in the group, which you have already accurately determined on your drawing. For lateral distances again—that is measurements to right or left—make a constant comparison between them and the width of the group, or between them and some *particular* width which you have already determined on your drawing. Proceed in this careful manner until the first sketch or *block* of the group is completed, which ought to be done with exceedingly light lines.

Fifth. Examine your work. To do this effectively, hold your drawing upright so as to have a full view of it at arm's length or thereabout, and also to see the group just past the edge of your paper. In this position, compare the drawing as a whole with the group as a whole. If no error can be observed in the principal proportions of the entire mass, then proceed to compare the different portions of the drawing with the corresponding portions of the group, and lastly, compare the smaller details in the drawing with the corresponding details of the group. If no error can be detected, then line in and finish the drawing.

By fixing at the commencement on the size of the group on your paper, you thereby determine the distance from which your drawing, when completed, is to be viewed, so as to appear perspectively correct. Bear in mind, that in drawing from an object, you are merely endeavouring to produce on your paper, such an arrangement of lines as would be obtained by tracing the outlines of the object on an upright transparent plane, interposed between it and the eye. When, therefore, you determine the distance from the eye at which such a tracing is to be made, you thereby determine its size as well as the exact length of every line therein, and if you first determine the size of your drawing, you, in consequence, determine the distance from which it ought to be viewed.

Sufficient practice may be obtained from very few models, either by changing the position whence the group is to be drawn, or by changing the grouping of the models. If you require to draw to the full size of the group, measure its true vertical height. Lay this height down on your paper as the height of the drawing, and complete the sketch as above directed. To examine such a drawing it is necessary to place it beside the model, and make the comparison from the position where the drawing has been executed. If you require to draw to a half, a third, or a fourth, &c., of the size of the model, you must take a half, a third, or a fourth of the vertical height for the height of your drawing, and in examining such a drawing it must be placed at a distance from you of a half, a third, or a fourth of your distance from the model.

LESSON XIX.—Model Drawing.

WHEN a circle is so placed that its plane is parallel to the *P P*, and its centre coincides with the *C V*, it is represented by a circle.

When a circle is so placed—edgeway towards you—that the line of vision lies in the plane of the circle, it is represented by a straight line.

When a circle lies in any other position, with its centre in the line of vision, it is represented by an ellipse, and may be sketched in the following manner:—

Observe the direction in which its apparent longest diameter lies. Represent this diameter on your paper by a straight line drawn in a corresponding direction, as compared with a horizontal, or with a plummet line. Bisect this line at right angles by a shorter one. Ascertain, by pencil-measurement, the apparent width of the circle taken at the middle of, and at right angles to, the longest diameter. Determine the proportion which the shorter diameter bears to the longer, and make the two corresponding lines on your paper bear the same proportion to each other; taking care to have one-half of the shorter line on either side of the longer. Draw the curve through the extreme points of these two lines. In doing so, observe that the curve towards the ends of the longer diameter is full and round, and not pointed, as you will be apt to make it.

Bear in mind that the long line which you have drawn to represent the longest diameter of the ellipse, does *not* represent a real diameter of the circle. The perspective position of the centre of a circle, when viewed obliquely, lies nearer to the far edge of the circumference than to the near edge; and hence a true diameter of the circle would be represented by a line lying somewhere beyond the line which you have drawn. In order to understand this clearly, it may be necessary to test your sketch of a circle, drawn according to the above method, by the geometrical method shown in Lesson X.

The above method is based on the supposition that each circle is drawn on a vertical plane at right angles to a line from the eye to the centre of the circle. It is therefore not theoretically correct for a circle in a different position, but it will be found in all cases a good serviceable rule for beginners in model drawing.

In drawing a cylinder, cask, vase, jar, or other symmetrical circular object, when its axis is at right angles to the *C L V*, observe the following rules:—

Determine on your paper the height of the vase. Ascertain, by pencil measurement, its greatest width in correct proportion to its height, and mark on your paper a width in the same proportion to the height fixed on for the vase, &c. Let this width be marked in true relation to other objects in the group, of which the vase may form a part. Through the middle of this width draw a vertical line. This vertical line is the axis of the vase in its true position. The contour must then be drawn to balance on both sides of this line.

When the axis of the vase, cask, or jar, &c., is horizontal, but oblique to the *P P*, proceed as follows:—Find the *V P* of the axis. Determine on your drawing the greatest width of the object, and this in true relation to the other objects in the group. Through the middle of this width draw a line towards the *V P* found. Determine the foreshortened length of the object and draw the circular ends, &c., according to the rule given above.

It will often be necessary (in order to secure accuracy in the sketch) to complete the circles, though part of them only may be seen. This, of course, should be done with very light lines, so that they may be easily erased when the drawing is being lined in.

Good private practice may be obtained from any circular object at hand, such as a flower-pot, cup, or wine-glass. First sketch the object selected when standing in its ordinary position and on a level with the eye. Next place it below, and then above this level; and make a drawing of it in each position. Lay it then on its side, and turn it round about the eighth of a circle for every new sketch you wish to make. Continue this practice until some facility has been acquired in drawing circular objects placed in any position.

LESSON XX.

THE block on the plate is 9 feet high; has a square base of 4 feet side, and tapers to a square of 3 feet side at the top. The horizontal square slab on the top is 1 foot thick and 6 feet side, and has its centre directly over the centre of the block; the edges of both slab and block being parallel. The near corner of the slab is 1 foot into the picture, and 2 feet to the left of the *C L V*, and its sides, which incline to the right, make 40 degrees with the *P P*. Distance 12 feet; height of the eye 5 feet; scale $\frac{1}{3}$ of 1 inch to a foot, or $\frac{1}{36}$.

Lay down the plan as in the plate. Draw it in perspective, having the near corner of the outer square 1 foot into the picture, and 2 feet to the left. The base of the block is represented by the intermediate square. The inner and outer squares are then to be raised to their true height above the ground. In order to do this, draw a line through the near corners of these squares, and produce it, to meet the *P L* and the *H L*, in *o* and *X* respectively. Part of this line is a diagonal of the squares in perspective. Make $o\,Q = 9$ feet, and join *Q X*. The line *o Q* is an edge view of *a* retiring vertical plane 9 feet high, at the *P P*, passing through the centre of the object, and vanishing in *X*. Draw vertical lines from the near corners of the squares on the ground till they meet *Q X*. The points found are the near top corner of the block and the near lower corner of the slab. From these points draw lines to $V P^1$ and $V P^2$. These are the retiring lines of the top front edges of the block, and the lower front edges of the slab. From the right and left corners of the squares on the ground, erect vertical lines till they meet these retiring lines in the right and left top corners of the block, and the right and left lower corners of the slab. Draw the far lower lines of the slab, and complete the upper portion of it, by showing the thickness, and the drawing is finished.

Questions.

1. The height of the nearest upright edge of a box is 2 feet, and it is 12 feet distant. What will be the height of this edge on your drawing, when the drawing is intended to be looked at from a distance of 1 foot? 2. What will the height be when the drawing is meant to be looked at from the distance of a yard? 3. A tower is 100 feet high and 100 yards distant. You wish to make a drawing of it on a picture to be looked at from a distance of a yard. On what scale must the drawing be constructed? 4. Suppose it is intended that the picture should be looked at from a distance of $1\frac{1}{2}$ foot: on what scale must the drawing be made?

Exercises.

1. Find a point (*A*) 4 feet to the right of the *C L V*, and 1 foot within the *P P* (which is 12 feet distant), and another point (*B*) directly in front, and 6 feet within the *P P*. Let the line *A B* be the side of a square, on which stands a pyramid 8 feet high; the nearest angle being 1 foot from the *P P*. Height of the eye 5 feet; scale $\frac{1}{24}$.

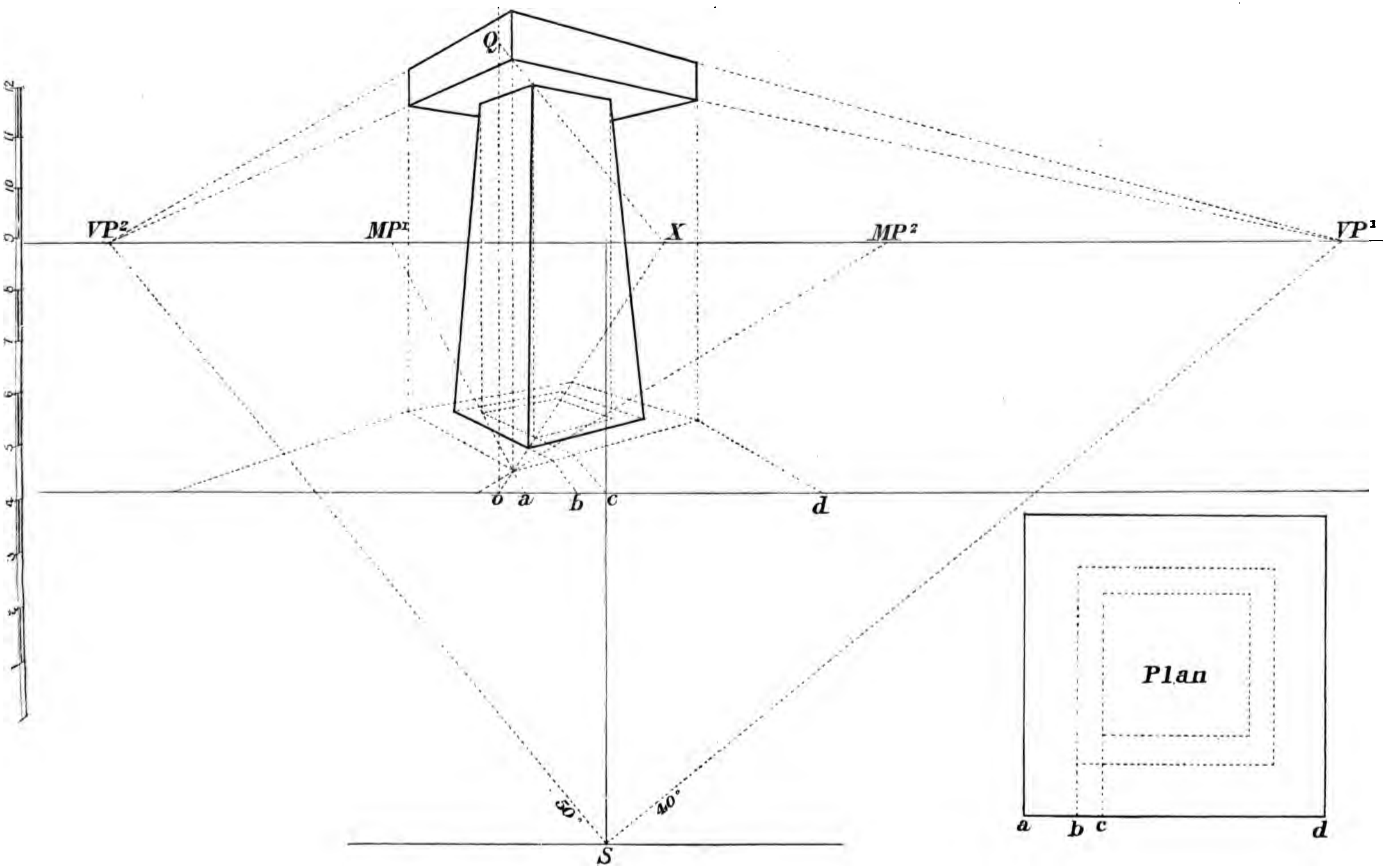
2. Suppose the pyramid is cut across by a plane parallel to the ground and 2 feet above it. Show this section in perspective, and find the distance of the farthest corner of the section from the *P P*.

3. "A hexagonal pyramid, 7 feet high, having 2 feet sides of base, stands on the ground plane; the centre of its base is 4 feet in the picture and 2 feet to the left. Two edges of the base are parallel to the picture plane. A square slab of 6 inches thick is pierced through its centre by this pyramid, and rests in a horizontal position upon it, at a level of 2 feet from the ground; its long edges are at equal angles with the picture plane and its nearest angle touches it." Distance 12 feet; height of the eye 5 feet; scale $\frac{1}{24}$.

4. "A right cylinder is 4 feet long and 4 feet diameter. The axis is vertical and touches the ground plane 3 feet in the picture, and 1 foot to the left. On this cylinder place a quadrangular pyramid 3 feet high, the edges of whose square base make equal angles with the picture plane, and are equidistant from the cylinder. One angle of the base touches the picture plane." Distance 12 feet; height 5 feet; scale $\frac{1}{24}$.

5. Suppose you are 15 feet distant from the near corner of the slab in the subject, as it stands in Lesson XX., and you move 4 feet to the left. Represent this block and slab on a vertical plane, 9 inches from the eye.

6. Find a point on the ground 4 feet to the left and 1 foot from the picture plane. Find another point 7 feet high, 3 feet to the right and 6 feet from the picture plane. Determine the length of the line which joins the points, supposing the station point to be 12 feet from the picture plane, and 5 feet above the ground plane.


Q
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LESSON XXI.—Linear Perspective.

THE exercise of last lesson is here repeated to show how it may be worked from a different base line :—

First. At A on the PL, 2 feet to the left, erect a vertical line. Make $AO = 9$ feet, and $O1 = 1$ foot. Through O draw a horizontal line BC. This is the base line from which measurements are to be carried into the picture. It is to be considered as an edge view of a horizontal plane, 9 feet high, or 4 feet above the height of the eye, in the same way that the picture or ground line is an edge view of a horizontal plane, a certain distance below the height of the eye. It is used precisely in the same manner as the PL.

Second. Find by parallel perspective, the near lower corner of the slab, 1 foot into the picture. Draw the near vertical edge, and from its top and bottom draw lines towards VP^1 and VP^2. From MP^1 draw a line through the near lower corner of the slab, and produce it till it meets BC in 2. Make 2, 5 = 6 feet. From 5 draw a line to MP^1. This line cuts the lower retiring line to the right, in the right lower corner of the slab. From this corner erect a vertical line, and the retiring right face of the slab is drawn. Draw the left face in a similar manner, and draw the far lower edges, and the slab is completed.

Third. Draw diagonals on the lower face of the slab and produce one of these to X on the HL, and join AX. Make 2, 6 = 1 foot and 6, 7 = 6 inches. From 7 draw a line to MP^1 till it cuts the lower edge of the slab. From the point so found draw a line to VP^2. This line will lie on the lower face of the slab, $1\frac{1}{2}$ foot from the left edge and parallel to it. It cuts the diagonal, which is produced to X in the near top corner of the block. From this corner draw lines to VP^1 and VP^2. These lines cut the other diagonal in the right and left top corners of the block. The lines of the top of the block are accordingly drawn.

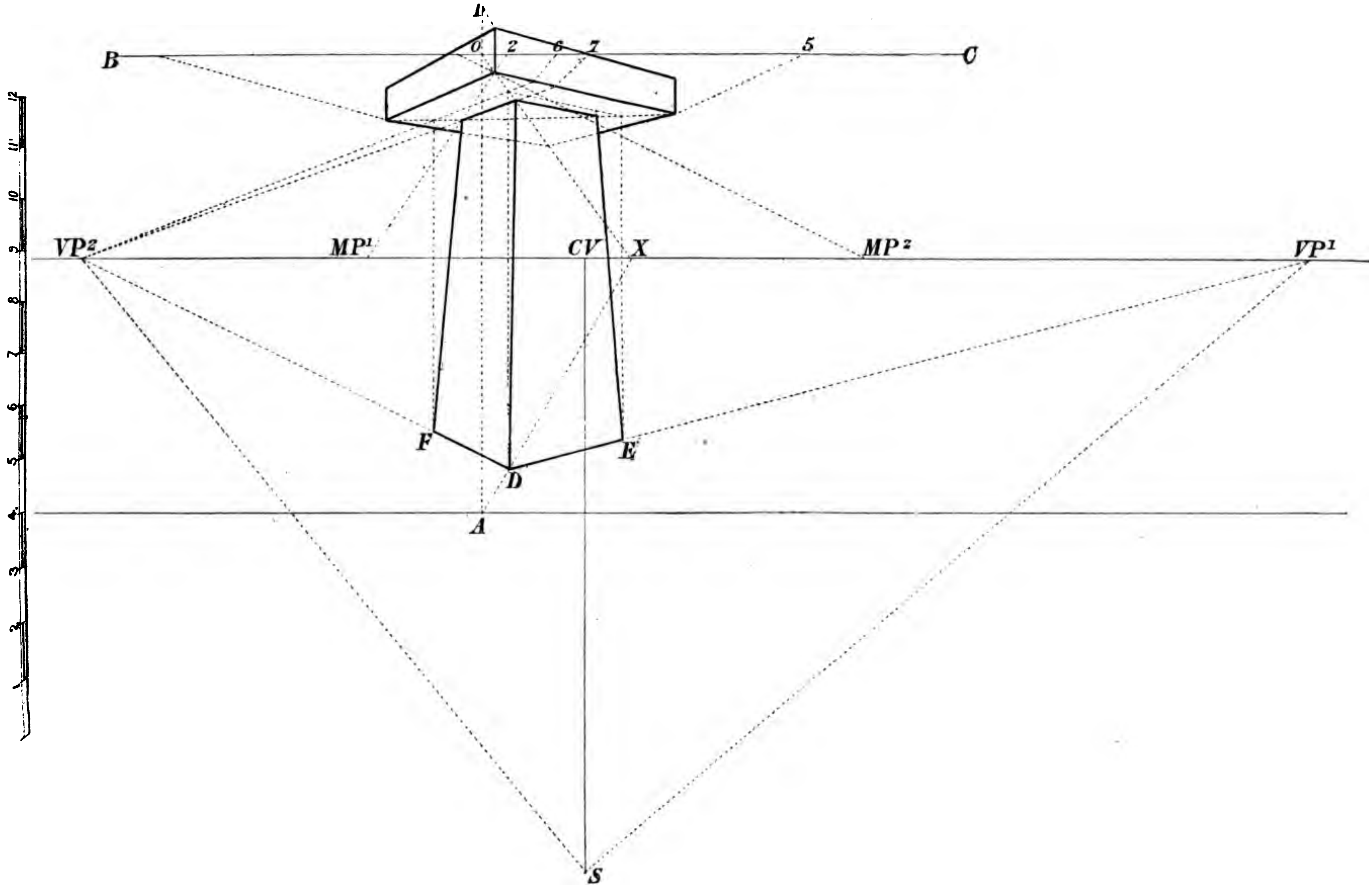
Fourth. From 6 draw a line to MP^1 till it cuts the lower edge of the slab. From the point so found draw a line to VP^2. This line cuts the diagonal which is produced to X in a point which is vertical to point D. From this point on the diagonal draw lines to VP^1 and VP^2. These lines cut the other diagonal in points which are vertical to F and E. From the point which is vertical to D drop a line till it meets AX in D. From D draw lines to VP^1 and VP^2, for the right and left retiring lines on the ground. From the points which are vertical to F and E drop lines to meet in F and E the lines on the ground retiring to right and left. From the points DEF draw the sloping lines to the top corners, and the drawing is completed.

Exercises.

1. A solid, 3 feet high, has a square base of 3 feet side and a square top of 2 feet side, and its nearest corner on the ground is 2 feet to the left and 2 feet in the picture. The sides which incline to the right lie at 30 degrees to the PP. A beam, 5 feet long by 1 foot square, rests centrally on the top, and lies lengthways, parallel to the sides of the block which incline to the left. Distance from the PP 12 feet. Height of the eye 5 feet; scale $\frac{1}{2}$ inch to 1 foot.

2. Show a section of the block and beam caused by a vertical plane making an angle towards the right of 45 degrees to the PP, which cuts the front base line of the block that inclines to the left, in a point 2 feet from the nearest corner.

3. A pillar, 9 feet high, has a hexagonal base with sides of $1\frac{1}{2}$ foot. At the top the hexagon is 1 foot side. A circular slab, 5 feet diameter and 1 foot thick, rests centrally on the top of the pillar. Two sides of the base of the pillar are parallel to the picture plane, and its axis is directly in front, and 6 feet in the picture. Distance from the PP 16 feet; height of the eye 5 feet; scale $\frac{1}{2}$ inch to 1 foot.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LESSON XXII.—Linear Perspective.

THE foregoing lessons have been confined to objects whose foreshortened lines lie in horizontal planes—that is, are parallel to the ground—and in consequence have their *V P s* and *M P s* on the *H L.* The following lessons treat of objects whose edges or lines make oblique angles with the ground, as well as with the *P P.*

Look at the block in Lesson XIII. The dimensions of it are 8 feet by 4 by 2, the nearest corner being 2 feet to the left of the *C L V,* and 2 feet into the picture. The long edges lie at 40 degrees to the *P P,* and are parallel to the ground. Now suppose that—without changing the position of the lower edge of the near end—the far end is raised till the long edges are at 35 degrees to the ground, you will have the block in the position shown in this plate, here drawn to a smaller scale. You proceed to learn how to draw an object in this or any similar position.

First. While the block lies on the ground the long edges are supposed to lie in horizontal planes. They may also be supposed to lie in vertical planes which are at 40 degrees to the *P P.* Now, in raising the block as suggested, while these edges rise out of the horizontal planes, they do not move out of the vertical planes. These vertical planes, making angles of 40 degrees to the *P P* in which the long edges still lie, must therefore be considered.

Second. VP^2 is the *V P* of horizontal lines which lie towards the right at 40 degrees to the *P P.* Suppose yourself standing at *S,* and looking directly towards VP^2. In this position your line of vision would lie horizontally at 40 degrees to the *P P.* A vertical plane standing at 40 degrees to the *P P,* directly in your line of vision, would become—since you would have an edge view of it—a vertical line passing through VP^2. This vertical line through VP^2 is the vanishing line of all vertical planes parallel to the direction in which you are looking, that is, all vertical planes lying towards the right at 40 degrees to the *P P.* It therefore bears the same relation to all such vertical planes, which the *H L* bears to horizontal planes.

Third. The *H L* is the vanishing line of all horizontal planes, and all horizontal lines have their *V P* somewhere on the *H L.* In the same way the vertical line *D E* is the vanishing line of all vertical planes which are at 40 degrees to the *P P,* and all lines lying in such planes have their *V P* somewhere on *D E.* The long edges of the block must therefore have their *V P* somewhere on *D E.*

Fourth. To find the *V P* and *M P* of the long edges. From MP^2 draw a line at 35 degrees to the *H L.* The point VP^3 where this line cuts *D E* is the *V P* required. From VP^3 as centre, with radius to MP^2, describe an arc cutting *D E* in MP^3, which is the *M P* required.

Fifth. To draw the lower edges of the block. Find, in the ordinary way, the edge which lies on the ground at 50 degrees to the *P P.* From the ends of this edge found, draw lines to VP^3. From any point on the *H L,* draw a line to *g* on the *P L* through the near corner of the block on the ground. Transfer the measurement, 8 feet, from a vertical line erected at *g* to a vertical line erected on this near corner of the block on the ground. From the point found, draw a line towards MP^3, and where it cuts the line retiring to VP^3, is the far end of the lower edge which lies at 35 degrees to the ground. From this point, draw a line to VP^1, and the lower face of the block is drawn. The short edges which are at right angles to the long ones are drawn in a similar manner. This will be shown in the next lesson.

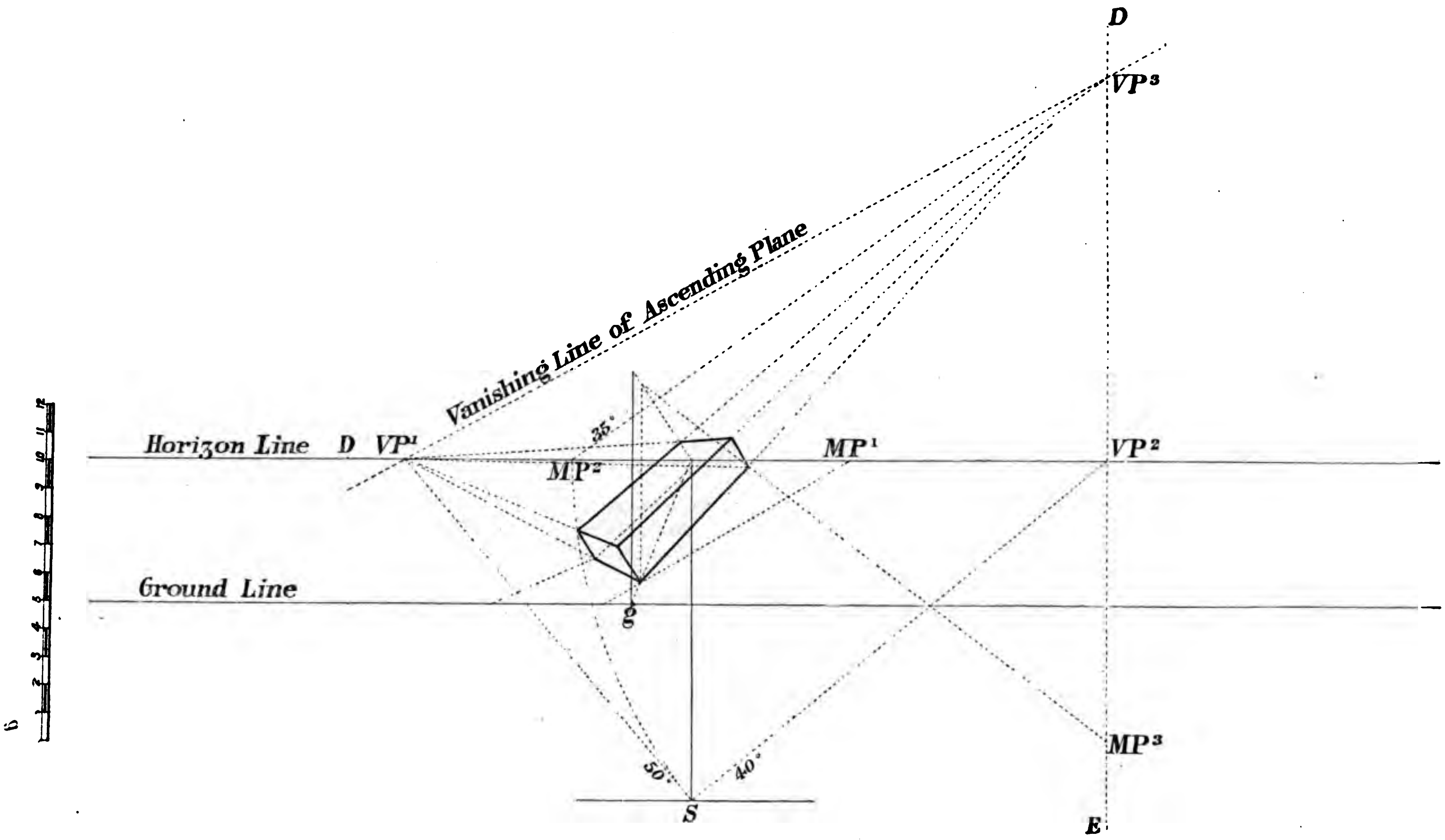
Vanishing points which are not on the *H L* are usually called **accidental vanishing points.**

Exercises.

1. A trap door on the ground plane is 5 feet long and 3 feet wide. The nearest corner is 12 feet distant and directly in front, and the long sides of the doorway lie towards the left at 45 degrees to the picture plane. The door is hinged on the most distant side and is opened so as to make an angle of 40 degrees to the ground. Draw this on a vertical plane 6 inches from the eye.

2. Suppose the door hinged on the near side, and opened to make an angle of 60 degrees to the ground, draw it on a vertical plane 8 inches from the eye, other conditions being the same.

3. A box 12 inches long, 7 inches wide, and 5 inches deep, stands on a table, with the nearest upright edge directly in front and 5 feet distant, the height of the eye being $1\frac{1}{2}$ foot above the table. The front of the box inclines to the right at 40 degrees to the picture plane, and the lid is opened at an angle of 45 degrees to the table. Draw the box on a vertical plane 6 inches from the eye.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VP³
Vanishing Line of Ascending Plane
35°
Horizon Line
D
VP¹
MP²
MP¹
VP²
Ground Line
g
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MP³
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LESSON XXIII.—Linear Perspective.

THIS is a continuation of the subject of last lesson.

The lines here denominated "upright edges," are those which represent the thickness of the block.

First. Since the long edges of the block are at 35 degrees to the ground, the upright edges, being at right angles to these, must be at 55 degrees to the ground, and their $V P$ will be below the $H L$. From $M P^2$ draw a line at 55 degrees below the $H L$, to meet $D E$ in the point $V P^4$. This is the $V P$ of the upright edges of the block. From $V P^4$ as centre, with radius to $M P^2$, describe an arc cutting $D E$ in $M P^4$. This is the $M P$ of the upright edges. Draw lines from the corners of the lower face of the block to $V P^4$, and produce them upwards to represent the direction of the upright edges.

Second. To find the depth of the block on one of these lines. Through the near corner of the block on the ground, from any point on the $H L$, draw a line to meet the $P L$ in g. Erect a vertical line at g equal to 2 feet, and find in the usual way this thickness on a vertical line erected on the near corner of the block on the ground. Join the top of this line to $M P^4$, and produce it towards the left till it cuts, in the point o, the retiring line of the upright edge. From o draw lines to $V P^3$ and $V P^1$ till they cut the retiring lines of the upright edges on the right and left. From the points found draw lines to $V P^1$ and $V P^3$, and the drawing is completed.

Third. The reason of the process for finding the accidental vanishing point $V P^3$ will be evident from the following. Suppose yourself standing at S, and looking horizontally at 40 degrees to the $P P$. You would be looking towards $V P^2$. Call the line from the eye to $V P^2$ "the horizontal line of vision." Suppose now that you direct the eye upwards from $V P^2$ towards D, till your line of vision is parallel to the long edges of the block. You would then be looking towards the $V P$ of the long edges, namely to $V P^3$, and your line of vision would be at 35 degrees to the ground. Call this line the "oblique line of vision." Now the line from $M P^2$ to $V P^2$, is a side elevation (or side view) of the horizontal line of vision, and the line from $M P^2$ to $V P^3$ is a side elevation (or a side view) of the oblique line of vision, and the triangle formed by the line from $M P^2$ to $V P^2$, the line from $M P$ to $V P^3$ and the line from $V P^2$ to $V P^3$ is a geometrical representation of the triangle formed by the horizontal and oblique lines of vision, together with the line from $V P^2$ to $V P^3$. This will be plain were the latter triangle conceived as swung round on the vertical line from $V P^2$ to $V P^3$ as on an axis, till it comes parallel to the $P P$.

Fourth. $V P^1$ and $V P^4$ are the $V P$ *s* of the parallel edges of the ends of the block. The line which joins them is the vanishing line of the planes in which the ends of the block lie. Any lines lying in such planes, or planes parallel to them, would have their $V P$ *s* somewhere in this vanishing line. The vanishing line of the planes in which the top and bottom of the block lie, is shown in the plate of last lesson, and is found in a similar manner, namely, by joining $V P^1$ and $V P^3$, which are the $V P$ *s* of the parallel edges of the top and bottom.

Exercises.

1. Show the vanishing line of a vertical plane which makes an angle toward the right of 65 degrees to the $P P$.

2. Show the $V P$ and $M P$ of lines lying in the above plane at 40 degrees to the ground.

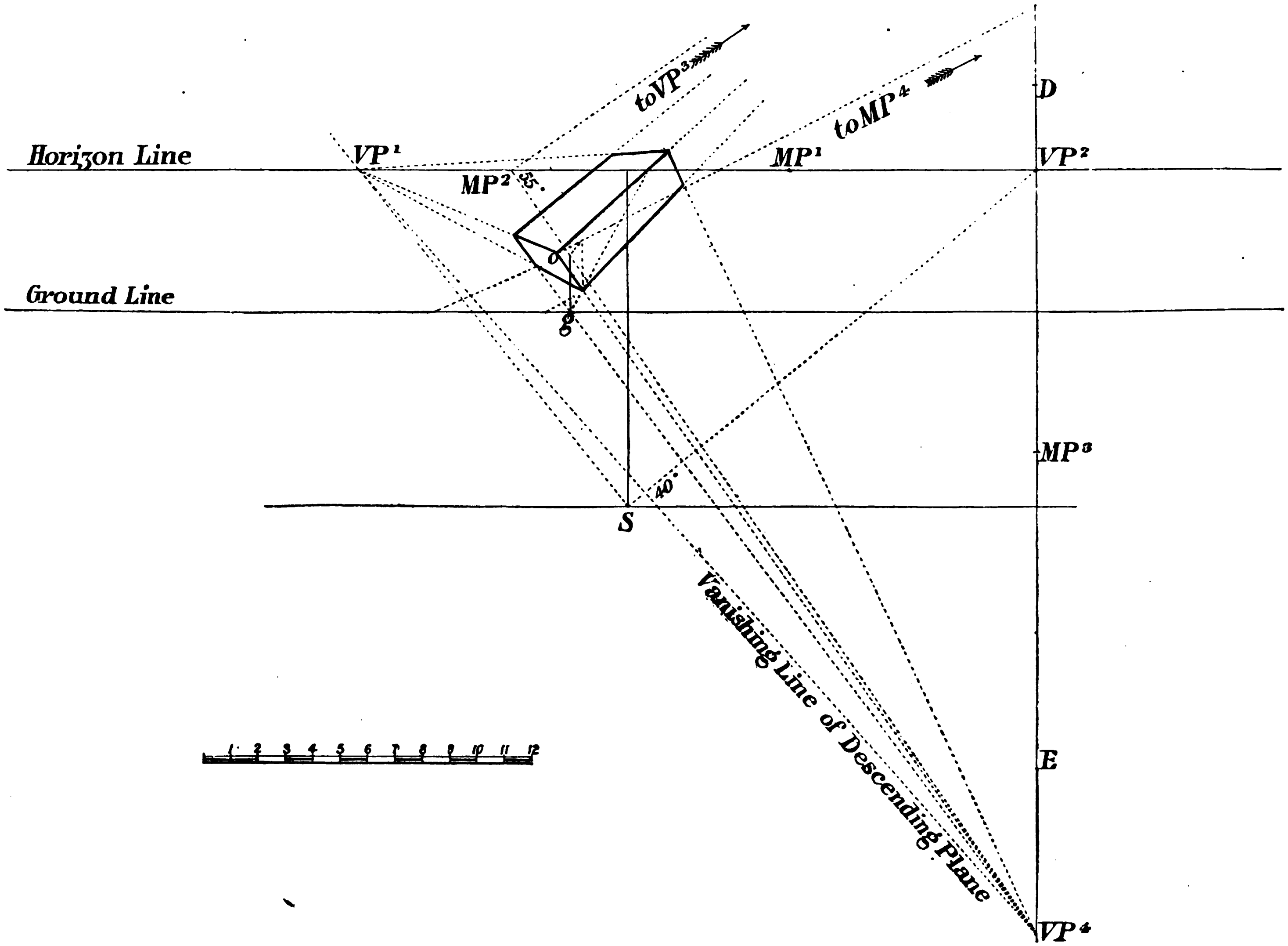
3. A line lies at an angle of 45 degrees to the ground in a vertical plane which makes an angle towards the left of 35 degrees to the $P P$. Find the $V P$ and $M P$ of this line.

4. Draw a line 4 feet long on the ground plane, which lies towards the right at an angle of 60 degrees to the $P P$, the nearest end being 4 feet from the $P P$, and 2 feet to the right of the centre. Let this line be the side of a square of which the plane lies at 40 degrees to the ground. Distance 12 feet, height of the eye 5 feet, scale $\frac{1}{24}$.

5. Let the square in the last exercise be the end of a rectangular block 6 feet long. Draw it.

6. Draw the block shown in this and last lesson,—8 feet by 4 feet by 2 feet—supposing the near corner on the ground is 3 feet to the right of the centre, and 2 feet from the $P P$. The long edges are at 45 degrees to the ground, and lie in vertical planes which incline towards the left at an angle of 60 degrees to the $P P$.

7. A box 6 feet long, 3 feet wide, and 2 feet deep, rests on the ground with its nearest corner 2 feet to the right of the centre, and 3 feet from the $P P$. The sides incline towards the left at 45 degrees to the $P P$. Draw the box having the lid opened at an angle of 60 degrees, the lid being hinged on the near long edge. Distance 12 feet, height of the eye 5 feet, scale $\frac{1}{24}$.


Horizon Line
Ground Line
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toVP³
toMP⁴
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Vanishing Line of Descending Plane
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LESSON XXIV.—Linear Perspective.

An octagonal prism 6 feet long rests on one of the edges of the octagonal end, and is so placed that its axis is at 40 degrees to the ground, and lies in a vertical plane which inclines to the right at 60 degrees to the *P P*. The nearest point (*a*) on the ground is directly in front, and is 6 feet from the *P P*. The side of the octagon is 2 feet.

This problem is here drawn to a scale of $\frac{1}{24}$ ($\frac{1}{2}$ inch to 1 foot) and in consequence the *S P*, the *V P s*, and *M P s* lie beyond the plate. The student ought to work this problem to the same, or even a larger scale; and he will be able to test the accuracy of his work by comparing it with the plate.

Draw first an elevation of the octagonal end and inclose it in a square. Represent the object as if it were a square prism, and on the ends of the prism find the points of the octagon.

The line erected at *O* on the *P L* is the measuring line, from which are transferred the measurements to the retiring edge of the end, and also the measurement (6 feet) to the long edge retiring to VP^3. If the last two lessons have been carefully studied, this problem, with the assistance of the plate, ought to present no difficulty.

Exercises.

1. A line 6 feet long touches the ground line 3 feet to the left of the centre, and makes an angle of 35 degrees to the ground. It lies in a vertical plane which inclines towards the right at 35 degrees to the *P P*. This line is the axis of a hexagonal pyramid lying on one of its faces. Draw the pyramid. Distance 12 feet; height of the eye 5 feet; scale $\frac{1}{24}$.

2. An octagonal slab 1 foot thick and 1½ foot side inclines to the ground at 45 degrees, while it rests on one edge which makes 30 degrees to the picture-plane. The nearest corner on the ground is directly in front and 5 feet in the picture. Draw it; the distance, height, and scale being the same as in last exercise.

3. A hexagonal prism 6 inches long, rests on a table on one of the edges of the hexagonal end, and is so placed that its axis is at 30 degrees to the top of the table, and lies in a vertical plane which inclines to the left at 45 degrees to the picture-plane. The centre of the base is directly in front and 4 inches from the picture-plane. Height of the eye above the table 1 foot, and distance from the picture-plane 2 feet; side of hexagon 3 inches; scale $\frac{1}{3}$.

4. A pentagonal prism rests on the table on one of its sides, with its axis inclined towards the right at 35 degrees to the picture-plane. The nearest point is 6 inches to the left and touches the picture-plane. Side of the pentagon 3 inches; length of prism 12 inches; distance 3 feet; height of the eye 1 foot; scale $\frac{1}{6}$.

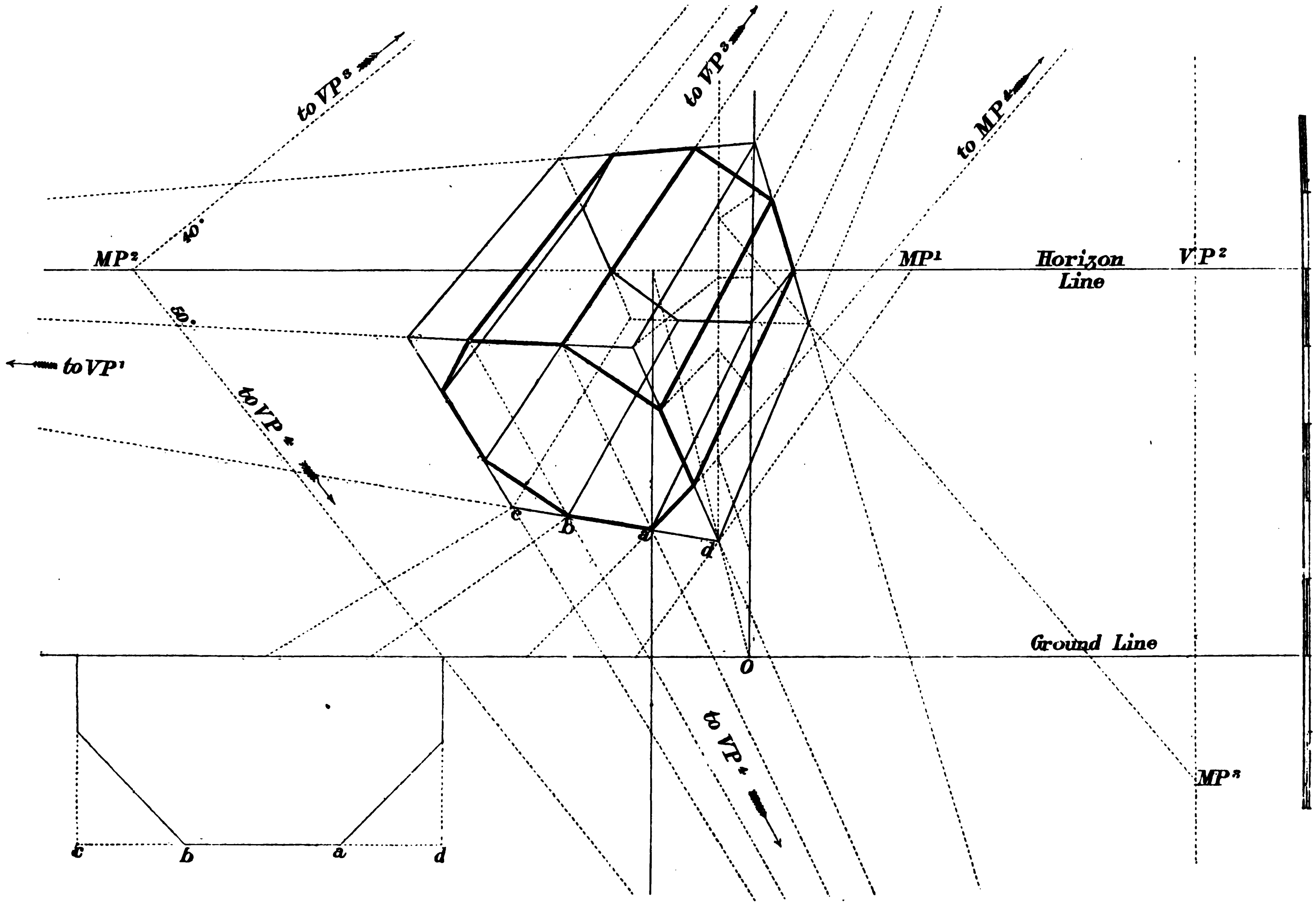
5. Show on the above pentagonal prism the section caused by a plane which is at right angles to the picture-plane, but inclined at 60 degrees to the ground, and which cuts the prism through the middle of the axis.

6. A circle 4 feet diameter has its centre directly in front, and lies in a plane at 45 degrees to the ground. This plane cuts the ground in a line which makes 40 degrees to the picture-plane. Draw the circle at the distance of 12 feet; scale $\frac{1}{24}$.

7. Let the circle in the last exercise be the base of a cone 6 feet high.

Note.—The line where a plane cuts a given horizontal plane such as the ground plane, is called its **horizontal trace**.

8. Find the vanishing line of an ascending-plane which makes an angle of 35 degrees with the ground, and whose horizontal trace is at 40 degrees to the ground line.


to VP³
to VP³
to MP⁴
40°
MP²
MP¹
Horizon Line
V P²
50°
to VP¹
to VP⁴
c
b
a
d
Ground Line
O
to VP⁴
MP³
c
b
a
d

LESSON XXV.—Model Drawing.

IN drawing from rectangular objects when the lines are oblique to the ground, it is necessary first to find the vanishing-points of such lines. This is done by looking in a direction parallel to the line whose vanishing-point is required. The point in space or on the background to which the eye is directed, is the vanishing-point of the line. This point must then be represented on the paper by a method similar to that which has already been explained in Lesson XV., with reference to horizontal lines that are oblique to the picture. Whether this point will be on or off the paper, of course depends on the size of the drawing relative to the size of the sheet of paper, as well as on the obliquity of the line whose vanishing-point is required. A little practice will enable the student readily to represent the vanishing-point of such lines. At first, however, in case of error, the drawing during its progress should be checked, by comparing the oblique lines with a vertical or horizontal line, while the original line in the object is compared with a plummet or horizontal line, according as the original line in the model inclines more to the vertical or horizontal position.

Practise first from a simple rectangular object, such as a box or large volume. Place it on the table so as to have its end towards you and its long lines parallel to your line of vision. Without moving the near lower edge, raise the far end about 45 degrees, and fix it in that position while you draw it. Turn it round the eighth of a circle towards the right, and afterwards the same distance towards the left, and draw it in each of these positions. Practise in a similar manner from other objects until you can draw them with comparative accuracy.

Questions.

1. How do you determine the *C V* on your sketch? 2. How do you find, on your sketch, the *VP* of any horizontal line? 3. How do you find the *VP* of a line which lies oblique to the ground? 4. Is there any difference in principle in the mode of finding these points?

LESSON XXVI.—Model Drawing.

LET a group, consisting of both rectilinear and circular objects, be arranged so as to have some of the sets of parallel straight lines in the models oblique to the ground, as well as oblique to the picture-plane. With the models thus set, make drawings of the group from different points of view, either by changing your own position, or by changing the position of the group by turning it round. Such a subject will afford practice in the application of all the rules hitherto given.

The object of finding the vanishing-point of any set of parallel lines is to secure the true convergence of such lines, as well as their direction. The true direction of a line may be fairly well approximated by comparing it with a plummet or horizontal line; but the true convergence of a set of parallel lines is often somewhat difficult to determine by this method. When, therefore, a set of parallel lines requires to be drawn whose vanishing-point has not been found in the ordinary way, the vanishing-point may be approximated by representing on your drawing two of the parallel lines, and producing them till they meet. All the other lines which are parallel to these two should be drawn towards this point. It will of course be remembered that when the object from which you are drawing is distant, the convergence of its parallel lines is less than when the object is near; and that the nearer the parallel lines lie in the direction of the central line of vision, the convergence is the greater.

In drawing from a group of objects you ought first to secure the correct proportions of the group as a whole. Having done so, secure the proportions of the larger objects before attending to the smaller, and leave details to the last, bearing constantly in mind the law which governs parallel lines.

Questions.

1. What is the object of finding the vanishing-point of a set of parallel lines? 2. How may the true direction of an oblique line in the model be fairly well obtained in your sketch? 3. Following this method, how may you determine the vanishing-point of a set of parallel lines? 4. State in detail the method you ought to follow in sketching from a group of objects.

Model Drawing.—Concluding Remarks:

One further remark may be added by way of specific direction to the student. In drawing an object which consists of several distinct parts, such as a skeleton cube, a chair, or a table, &c., in whatever position it may be placed, the best method will generally be to sketch it in *block*, and then out of this solid, *map*, or in a manner, *hew* the form which is wanted. The particular method, however, by which any individual object is thus to be drawn in its details may be left to the intelligence of the student, who throughout his work constantly applies to it the test of accuracy; and he who has fully mastered these lessons as well as grasped their purpose, will quite naturally adopt those methods which are the easiest and the best.

In the foregoing lessons the most important rules for systematic working are laid down, while they also indicate the course which the student ought to pursue in order to gain confidence and expertness in sketching from objects. In his daily practice, he ought to adhere closely to the rules here given until he is able, almost instinctively, to lay down on his paper the points or lines which may be required. In the course of time he will be able to dispense with the rule altogether, but he must not expect to be able to draw with facility and correctness even these apparently simple things here suggested, without regular and careful work. The ability to draw is not to be acquired in a day, any more than the power to write or speak a foreign language, and the acquisition of either requires a certain amount of preparatory and somewhat uninteresting training. But as the student, day by day, completes his drawing study, he has the satisfaction of knowing that he is actually learning something about the form of objects, and that every successive drawing is helping him to lay a solid ground-work on which any future advancement may be safely based. To make a correct outline of a group of ordinary school models, of a few books laid on the table, of a growing plant, or a few shells, appears a simple matter to those only who have not tried it, but is really so only to those who have gone through a certain amount of training, similar in kind to what has here been inculcated. As to the actual course of work which he is to pursue as well as the particular subjects which he ought to attempt, the student must be guided by his teacher, since there is little real good to be derived from aiming at what is quite beyond his power. A little experience will teach him what is within his reach. While, in the meantime, he takes advantage of all rules and mechanical appliances, his ultimate aim should be to draw in a manner from feeling, or with entire comprehension of the apparent form of the subject of study. Having acquired facility in drawing the outlines of a group of school models, he ought to practise much from natural objects, such as plants, flowers, shells, &c., beginning with those whose form is most simple. Of course by the time the student has reached this latter stage of advancement, he ought, with the aid of flat examples, to be able to produce a piece of flat or a piece of uniformly graduated shading either with the point or the stump, and be ready to commence the study of light and shade from the solid, which is the next step in his progress towards the acquisition of a knowledge of the expression of form. This continuation of the subject, however, lies beyond the scope of this manual, which is intended only as a practical guide to linear perspective drawing.

LESSON XXVII.—Linear Perspective.

The block, 8 feet long by 4 feet by 2 feet, lies on an ascending plane which makes an angle of 40 degrees to the ground, and cuts the ground plane in a line parallel to the *P L*. The upright sides of the block lie in planes which are at right angles to the *P P*. The nearest corner of the block touches the *P P* 3 feet to the right of the *C L V*.

First. The vertical line through the *C V* is the vanishing-line of the planes of the sides of the block which are at right angles to the *P P*; and the long edges of the block, since they lie in these planes, have their *V P* and *M P* somewhere in this vanishing-line. For the same reason the upright edges—the edges representing the thickness of the block—have their *V P* and *M P* somewhere in the same line.

Second. Find *D*, the point of distance. From *D* draw a line to VP^1 at 40 degrees to the *H L*. Through VP^1 draw a line parallel to the *H L*. This line is the vanishing-line of the ascending plane. Any line lying in this ascending plane, or in a plane parallel to it, has its *V P* somewhere in this vanishing-line. MP^1 is found in the ordinary way by making VP^1 the centre and the distance to *D* the radius.

Third. From *D* draw a line to VP^2 at 50 degrees to the *H L* and below it. Through VP^2 draw a line parallel to the *H L*. This line is the vanishing-line of the parallel descending planes in which the ends of the block lie. Find MP^2.

Fourth. Find the nearest corner of the block on the *P P*, 3 feet to the right and at the height above the *P L* which is found on the elevation. Make the near edge of the end equal to 4 feet, and from the extremities draw lines towards V^1P and VP^2. Through *a* the near corner, draw a vertical measuring line from the *P L*, and make $ab =$ 8 feet and $ac = 2$ feet. Transfer these measurements to the retiring lines, and complete the drawing.

Fifth. The reason of the process for finding the vanishing-line of the ascending plane will be evident from the following: Suppose yourself standing at *S*—which you know to be, when in its true position, straight out from the *P P*—and looking at right angles to the *P P*. You would be looking towards the *C V*. Suppose now that you direct the eye upwards from *C V* towards *F* till your line of vision is parallel to the ascending plane, that is at 40 degrees to the ground. You would be looking towards the *V P* of the long edges of the block, namely, to VP^1. The triangle which would be formed by the three lines, namely, the ascending line of vision, the line of direction, and the vertical line from *C V* to VP^1 is represented in side elevation by the triangle formed by the line from *D* to VP^1, the line from *D* to *C V*, and the vertical line from *C V* to VP^1; just as if the first triangle were carried round a quarter of a circle towards the left, on the vertical line from *C V* to VP^1 as an axis.

Exercises.

1. Find the vanishing-line of an ascending plane which makes an angle of 40 degrees with the ground, and whose intersection with the ground plane, or horizontal trace, is parallel to the picture line.

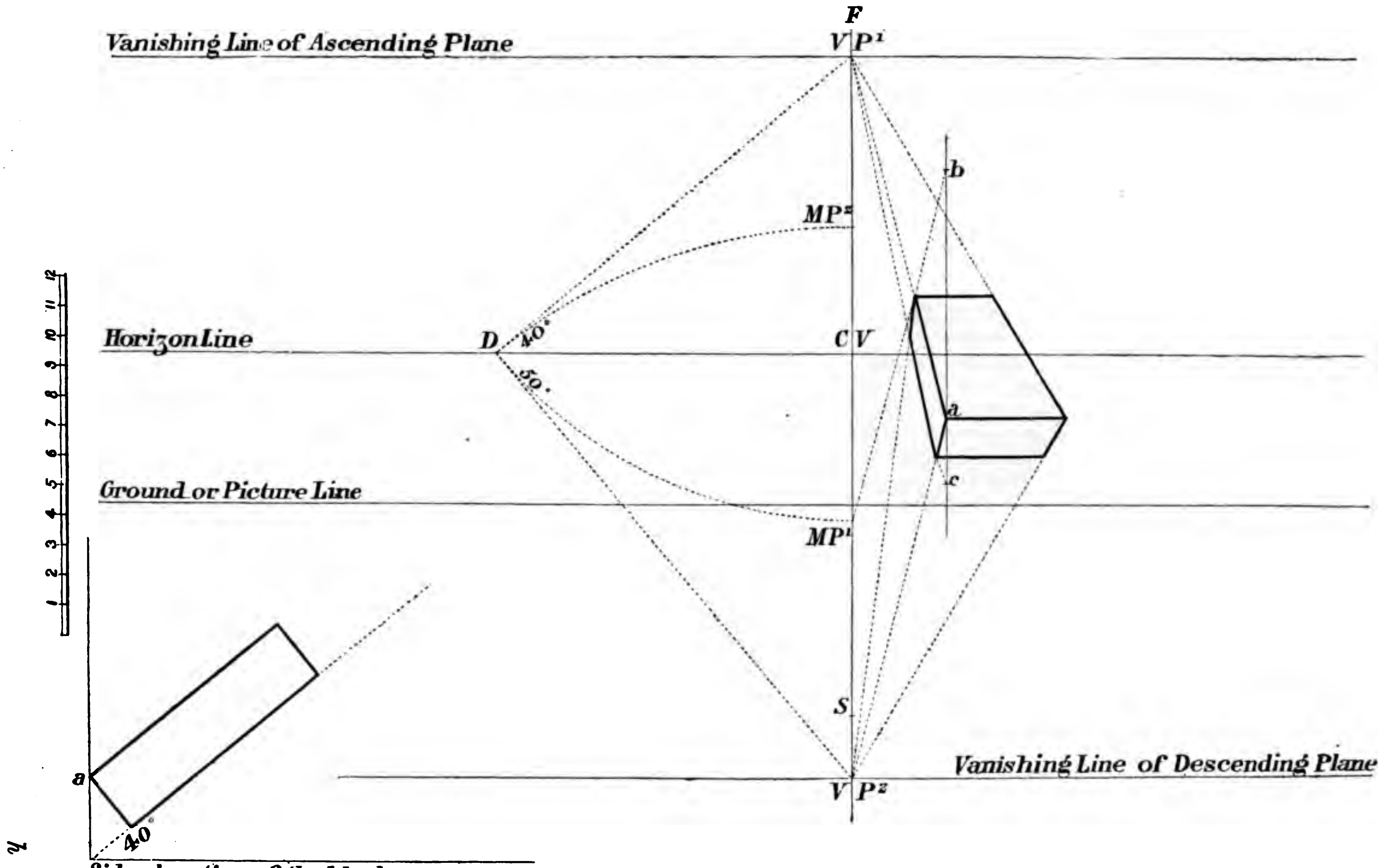
2. On the above vanishing-line find the *V P* of all lines lying—in that ascending plane—at right angles to its horizontal trace.

NOTE.—Erect a vertical line from the *V P* of these lines when lying on the ground. (This of course is the *C V*.) The point where it meets the vanishing line is the *V P* wanted. Apply this rule to any other lines on such a plane whose *V P* may be required.

3. Find the vanishing-line of a descending plane which makes an angle of 35 degrees with the ground, and whose horizontal trace is parallel to the picture line.

4. On the above vanishing-line find the *V P* of all lines lying towards the right—in that descending plane—and inclined at 45 degrees to its horizontal trace.

5. A block, 8 feet by 4 feet by 2 feet, lies on an ascending plane which makes an angle of 30 degrees to the ground, and cuts the ground plane in a line parallel to the *P L*. The upright sides of the block lie in planes which are at right angles to the *P P*. The nearest corner of the block touches the *P P* 4 feet to the left of the centre. Distance 16 feet; height of the eye 5 feet; scale ½ inch to 1 foot.



Side elevation of the block,
the ascending plane, the PP and the GP.

LESSON XXVIII.—Linear Perspective.

IN this lesson the block is so placed that all its edges make oblique angles with both the GP and the PP. The ascending-plane on which it lies makes an angle of 35 degrees to the GP, and intersects the GP in a line (AB) parallel to the PL, and 3 feet from the PP. The block touches the ground at the corner (a'), 5 feet to the left, and its long edges lie at 40 degrees to (AB) the line where the ascending-plane intersects the ground plane.

First. Through CV draw a vertical line of unlimited length. From D, the point of distance, draw a line at 35 degrees to the HL till it cuts this vertical line in X. Through X draw a horizontal line YZ. This is the vanishing-line of the ascending-plane.

Second. Through SP draw a horizontal line EF. This represents the line where a supposed plane parallel to the ascending-plane cuts the ground in SP, and whose vanishing-line is also YZ. From SP draw on this supposed parallel-plane to VP^1 and VP^2, lines at 40 degrees and 50 degrees to EF. Then VP^1 is the VP of the long edges of the block, and VP^2 is the VP of the edges of the ends. With VP^1 as centre and radius to SP determine MP^1. This is the MP of the long edges; MP^2 is found in a similar manner.

Third. At D draw a line downwards at 55 degrees to the HL till it meets the vertical-line through CV in VP^3. This is the VP of the upright edges of the block. Their MP is found in MP^3 by taking VP^3 as centre with radius to D.

Fourth. Point a on GL is 5 feet to the left. Make $a4 = 4$ feet, and $a8 = 8$ feet. Transfer these measurements to $a'4'$ and $a'8'$ on the base line AB. From a' draw lines to VP^1 and VP^2. From $8'$ and $4'$ draw lines to MP^1 and MP^2 respectively. These will determine points d and e. Complete the lower face of the block, and through the corners draw lines to VP^3. Erect a vertical line at $a =$ 2 feet. Transfer this in the usual way to the upright edge of the block at a', and complete the drawing.

Exercises.

A box, 14 inches long, 9 inches wide, and 7 inches deep, is placed on the table having its nearest low corner directly in front and $4\frac{1}{2}$ feet distant. The top and the bottom lie in planes which make an angle of 25 degrees with the top of the table, and would intersect the plane of the table in a line parallel to the PL. The long edges of the box incline towards the right and make an angle of 35 degrees with this line of intersection or horizontal trace. Height of the eye above the table 1 foot. Draw the box on a vertical plane 8 inches from the eye.

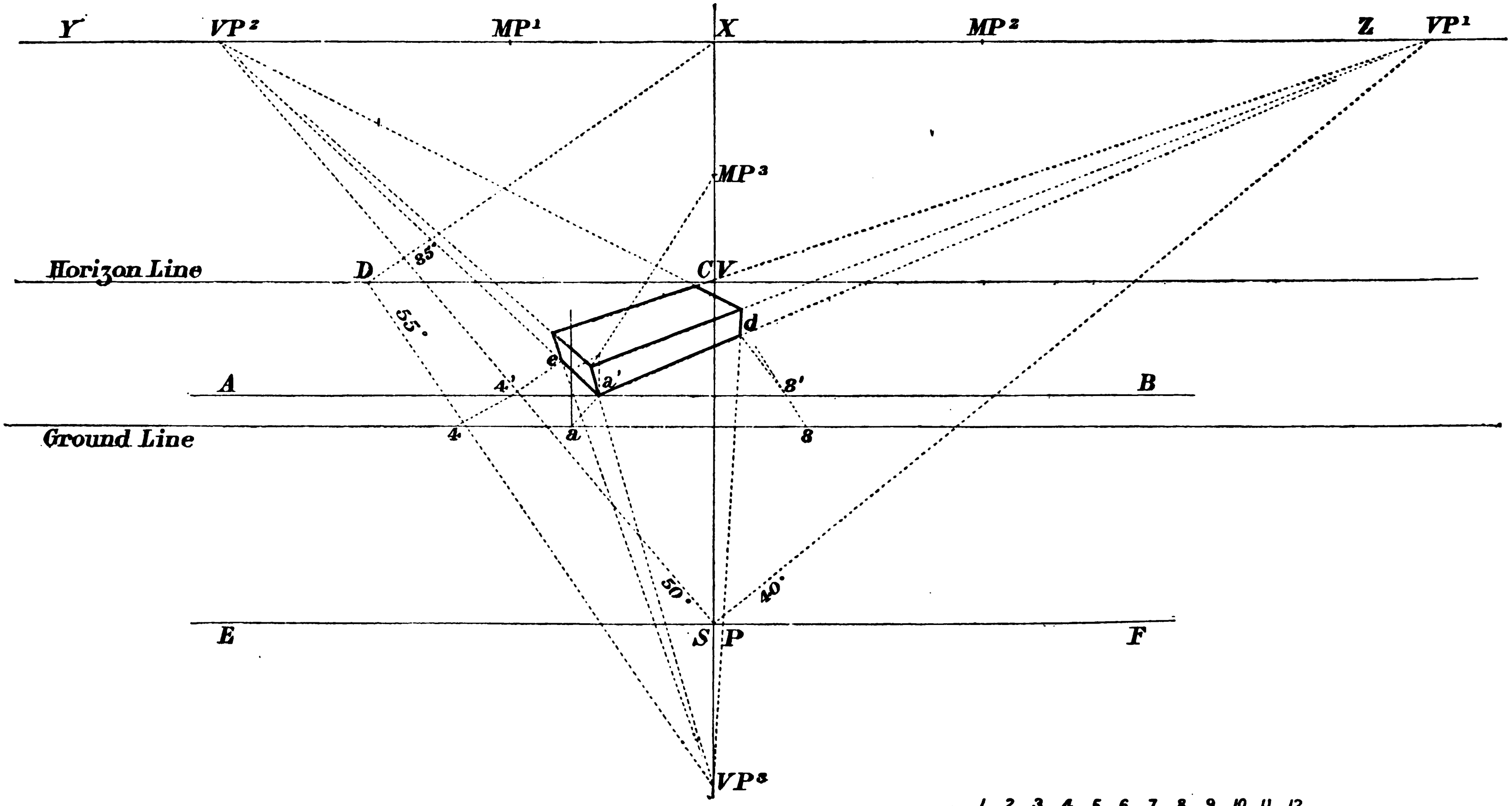
2. The horizontal trace of a plane lies towards the left at 40 degrees to the PL. The plane lies at 30 degrees to the ground. A circle, 5 feet diameter, lies in this plane, with its centre directly in front and 16 feet distant, but 3 feet below the height of the eye. Represent this circle on a vertical plane 1 foot from the eye.

3. Let the circle in the last exercise be the end of a cylinder 6 feet long. Draw the cylinder.

4. The horizontal trace of a plane lies towards the right at 35 degrees to the PL. The plane lies at 45 degrees to the ground. An octagon of 2 feet side lies in this plane with two of its sides parallel to the ground, its centre directly in front and 16 feet distant, but 4 feet below the height of the eye. Represent this octagon on a picture plane 1 foot from the eye.

5. Construct the octagon in the last exercise into an octagonal pyramid 6 feet high.

6 A point directly in front is 12 feet distant and 5 feet below the level of the eye. From this point draw a line 6 feet long at an angle of 45 degrees to the ground, in a vertical plane which inclines towards the right at 45 degrees to the PP. Let this line be the axis of a cylinder 4 feet diameter. Represent this cylinder on a picture plane 8 inches from the eye.


Y
VP²
MP¹
X
MP²
Z
VP¹
MP³
Horizon Line
D
85°
CV
55°
d
e
a'
4'
8'
A
B
Ground Line
4
a
8
50°
40°
E
S
P
F
VP³
1 2 3 4 5 6 7 8 9 10 11 12

LESSON XXIX.—Linear Perspective.

HERE again the block is so placed as to have all its edges at oblique angles to both the *G P* and *P P*; but the ascending-plane on which it lies cuts the *G P* in a line oblique to the *P L.* In other words the horizontal trace of the ascending-plane is oblique to the *P L.*

The plane on which the block lies is at 40 degrees to the ground, and its horizontal trace lies towards the left at 45 degrees to the *P L.* The block touches the ground at one corner only, which is 9 feet to the left of the centre and 9 feet into the picture, while its long edges lie at 25 degrees to the ground.

The easiest method of working the problem under these conditions is shown on the plate. In the figure to the left the block is drawn in plan, in its true relation to the horizontal trace, which is there represented by *a*, *b*. The long edge 2, 5, is drawn at an angle of 25 degrees to the line *a*, *b*, and the plan of the block is inclosed in the rectangular figure 8, 1, 4, 7; one side 1, 4, being part of the line which represents the horizontal trace.

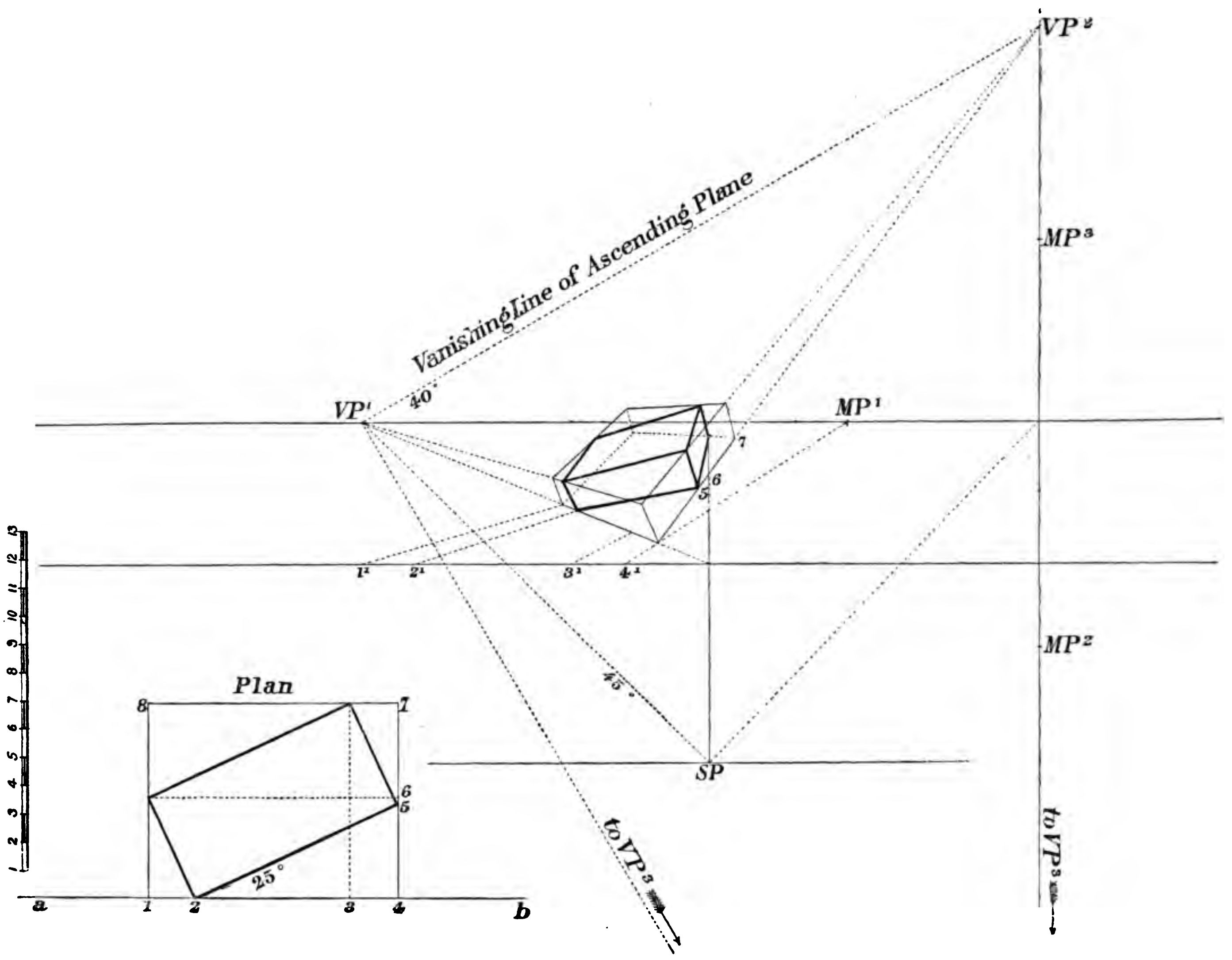
The rectangular figure 8, 1, 4, 7, is then represented in perspective. The point 2 in the line 1, 4, is placed 9 feet to the left and 9 feet into the picture, and the line 1, 4 lies on the ground at an angle of 45 degrees to the *P L.* The lines 4, 7 and 1, 8 are in a plane at 40 degrees to the ground and vanish to $V P^2$.

The points where the inclosed block meet the sides of the large rectangular solid are then found in the usual way, and the drawing of the block is completed.

In order to avoid a confusion of constructing lines, the transfer of the measurements from measuring lines on the *P P* to the lines in the drawing which are oblique to the ground, are not shown on the plate. But the *V Ps* and *M Ps* which are required, are marked, to enable the student to examine the drawing by supplying these measuring lines, should he find this necessary.

$V P^3$ which is off the plate, is the *V P* of the short upright edges, $M P^3$ being their *M P.* $V P^2$ is the *V P* of the edges of the large rectangular block, which lie at 40 degrees to the ground, and $M P^2$ is their *M P.*

The line marked "vanishing-line of ascending-plane," is the vanishing-line of the plane on which the block lies. Were this line continued below the horizon-line, the part below the horizon-line might then be called "the vanishing-line of the descending-plane." The entire line is the vanishing-line of the oblique plane in which the block lies, and on producing the parallel lines in the block which lie in this oblique plane, it will be found that they meet in this line, one set meeting it above, and the other below the horizon-line.


VP²
MP³
Vanishing Line of Ascending Plane
40°
VP¹
MP¹
7
6
5
1¹
2¹
3¹
4¹
MP²
45°
SP
to VP³
to VP³
Plan
8
7
6
5
25°
a
1
2
3
4
b
1
2
3
4
5
6
7
8
9
10
11
12
13

LESSON XXX.—Linear Perspective.

THE object of this lesson is to explain another method by which a given subject may be represented in perspective. In principle it is simpler than the method already explained, as there are no measuring points required, and the theory of the entire process is thus more easily comprehended. It is simpler also in practice for such as architectural and other subjects which have an elaborate plan, and consequently may have many horizontal measurements on different vanishing-lines. It is, however, not the most expeditious method for working ordinary perspective problems. In order that a comparison may be made between the two methods, the subject here chosen is that of Lesson XIII., but drawn on a smaller scale, so as to include in the plate all the lines and points required.

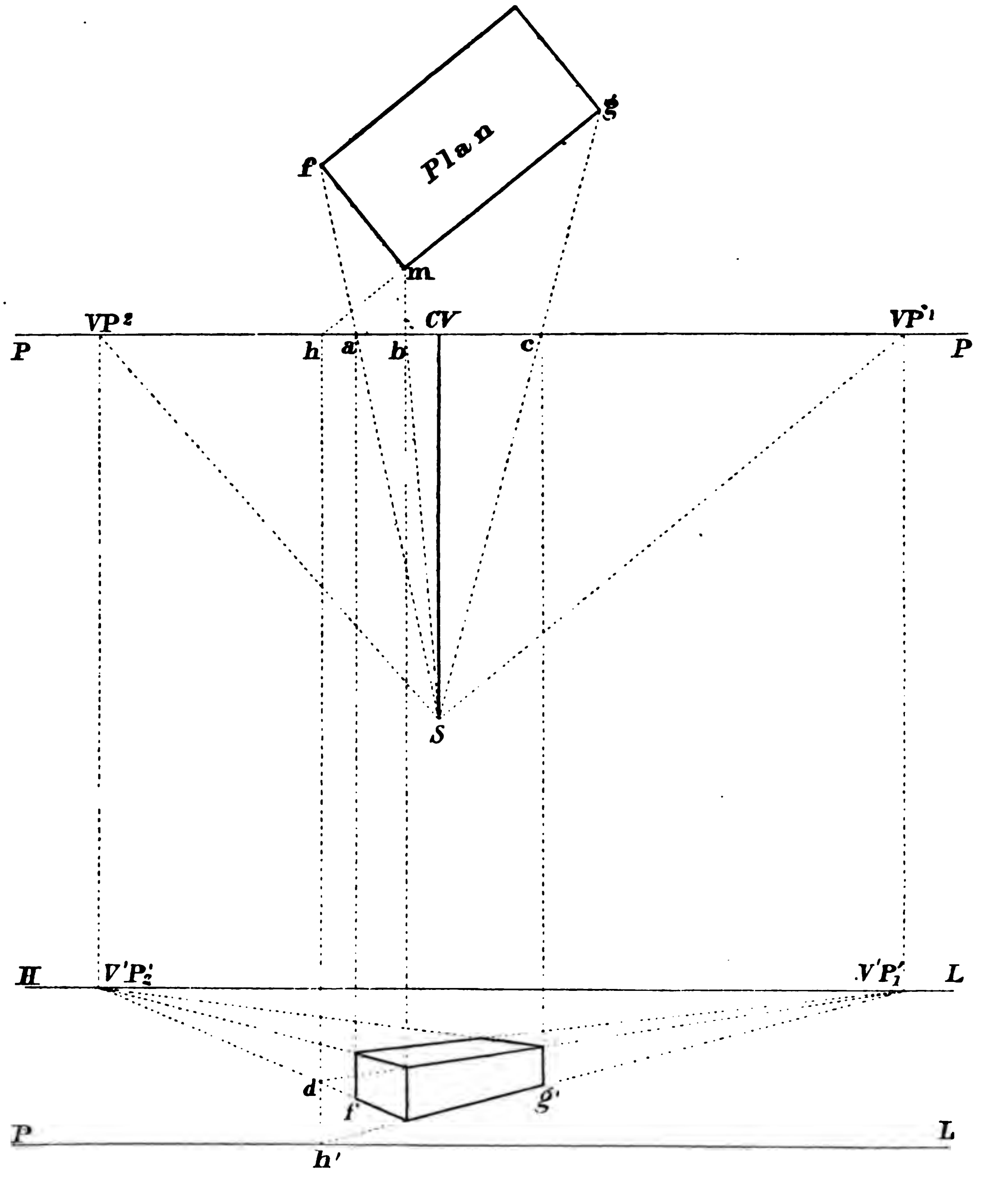
A rectangular block, 8 feet long, 4 feet wide, and 2 feet thick, lies on the ground, having its nearest corner 1 foot to the left of the *C L V*, and 2 feet into the picture. Its sides lie at 40 degrees and its ends at 50 degrees to the *P P*.

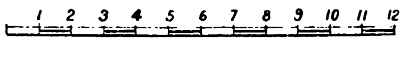
First. Draw the line *P P* to represent a plan of the picture-plane, that is such a view of it as you would obtain were you looking down upon it. Determine the *C V*, and from it draw a line to *S* at right angles to the *P P* and equal to 12 feet. The point *S* is the station-point in plan. Place the corner *m* a distance of 2 feet back from the *P P* and 1 foot to the left of the *C V*. Draw the side and end of the block at 40 degrees and 50 degrees respectively to *P P* and complete the plan of the block. Thus you have the block, the *P P*, the station-point, and the central-line of vision drawn in plan in their correct relative positions.

Second. Draw lines from all the visible corners (*f m g*) of the block through the *P P* to *S*, to represent the rays of light which come from these points to the eye. They cut the *P P* in *a b c*. The distances *a b* and *b c* represent the perspective lengths of the end and side of the block on the picture-plane. Find VP^1 and VP^2 in the ordinary way.

Third. Anywhere below (or above) this plan, with T square, draw the *H L* and the *P L* 5 feet apart. Drop vertical lines from VP^1 and VP^2 to find the vanishing-points on the *H L*. Produce the side of the plan of the block to meet *P P* in *h*. From *h* drop a vertical line to meet the *P L* in *h'*. From *h'* draw a line to $V'P'^1$. This line represents in perspective the retiring-line of the long edge of the block on the ground. From *b* drop a vertical line to find on this retiring-line the near corner of the block, and from the point found draw a line to $V'P'^2$. From *a* and *c* drop vertical lines meeting these retiring lines to $V'P'^2$ and $V'P'^1$ in the right and left corners (*f'* and *g'*) of the block on the ground. From *h'* erect a vertical line which will represent an edge view of a plane, coinciding with the near side of the block and vanishing towards $V'P'^1$, and which is to be used for cutting off any required height in that plane. Make *h d* = 2 feet the thickness of the block. From *d* draw a line to $V'P'^1$ and you have the near side of the block. Draw the upper edges of both ends and the upper edge of the far side, and the drawing is completed.

The upper and under parts of the plate might have been drawn on separate sheets of paper if necessary. The object of the upper part of the construction is to obtain the perspective lengths of the side and end of the block. Here they are *a b* and *b c*, and these are transferred to the perspective drawing as shown, merely because it is the most convenient method for the size of the plate. Were you making a large drawing of a complicated architectural subject you would mark off on a slip of paper the line of horizontal measurements, and from this slip transfer them to the *P L* on your perspective drawing. For ordinary exercises, however, the method shown will be found suitable. It is also only a matter of convenience the finding of the *V Ps* on the *P P*. They might have been found on the *H L* in the usual way, but this would have necessitated another construction similar to that on the upper part of the plate.


Plan
f
g
m
VP²
CV
VP¹
P
h
a
b
c
P
S
H
V'P'₂
V'P'₁
L
d
f'
g'
P
L
h'


1 2 3 4 5 6 7 8 9 10 11 12

APPENDIX A.—Measuring Points.

Let HL in FIG. I. represent the horizon-line, S the station-point, V a vanishing point, SV a vanishing-line, and M its measuring point, all laid down in plan.

SV being equal to VM the triangle SVM is an isosceles triangle, of which SM is the base. From S draw SD parallel to HL, and in SD take any points a, b, and c. From a, b, and c draw lines a^1, b^2, c^3, parallel to the base SM and produce them. It is plain that $Sa = S^1$, $Sb = S^2$, $Sc = S^3$, $ab = 1, 2$, and $bc = 2, 3$.

Again, take any point E in SM and draw a line EF parallel to SV. It is also clear that the divisions $Sa = E^4$, $Sb = E^5$, $Sc = E^6$, &c.

Bear in mind that HL represents the horizon-line, and that the distance from S to C is infinite in extent—the whole figure being on the ground-plane.

Imagine now FIG. I. to be on a *vertical* plane at an immense distance off, with the line HL on a level with the eye, and the point C directly opposite. Suppose the line HL is a hinge and stationary, and that the lower part of this vertical plane is swung forward and raised towards you until the line SD coincides with the picture-line. It is clear that the plane would assume an appearance similar to FIG. II. where the measurements on Oc are the same as on FIG. I. but are reduced to their perspective representation on the vanishing line OV. Hence it appears, that in perspective, real measurements are reduced to their foreshortened dimensions on a vanishing-line, by drawing lines parallel to the base of an isosceles triangle of which the vanishing-line is one of the sides, the opposite angle of the base—that is the MP—becoming the vanishing-point of these parallel lines.

APPENDIX B.—Examination Papers.

SECOND GRADE PAPERS OF THE SCIENCE AND ART DEPARTMENT.

1. Find a point (A) on the picture-line 4 feet to the left. From A draw a line vanishing at 60 degrees to the right. On this line find two points B and C respectively 3 and 6 feet to the right from A. Let BC be the side of an equilateral triangle upon which, as a base, rests a solid 3 feet high in a vertical position.

2. Put in perspective a circle, 3 feet radius, centre 3 feet to the right and 4 feet within the picture. On this, as a base, place a cylinder 7 feet high.

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1. A regular octagonal prism, of 1½ foot edge at base and 8 feet in length, lies upon the ground-plane. Its base inclines to the left at an angle of 30 degrees with the picture-plane. The nearest side of the base is 4 feet within the picture and 2 feet to the left. Give a perspective representation of the solid.

2. Find two points in the ground-plane, one of them being 6 feet to the right and 1 foot in the picture, and the other 4 feet to the right and 8 feet in the picture. On the line between these points put in perspective a semicircle in a vertical plane.

3. Define the point of distance.

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1. Give a perspective representation of a cube standing on the ground-plane with one edge touching the picture-plane 4 feet to the right of the spectator, and its other sides vanishing at 45 degrees.

Fig. I.

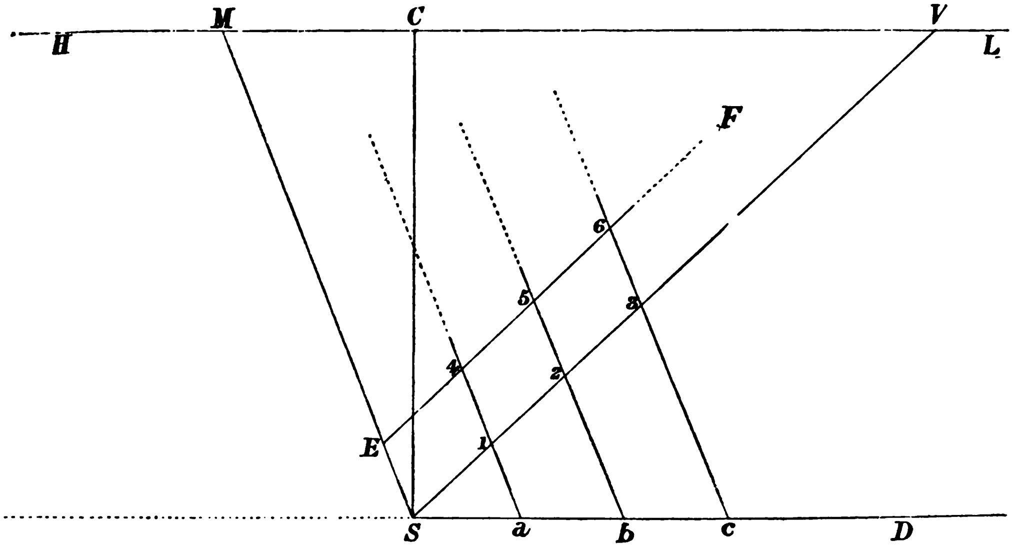
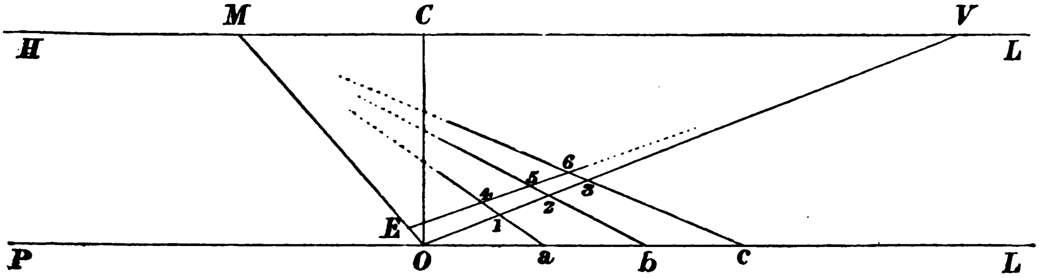


Fig. II



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2. Find a point 2 feet to the left and 2 feet in the picture; and another 5 feet to the left and 7 feet in the picture. Join these two points (*A* and *B*) and find the real distance from *A* to *B*.

3. Give a definition of picture-plane.

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1. The axis of a right cylinder 4 feet in diameter and 6 feet in length is vertical, and 3 feet to the left of the spectator and 3 feet within. Give a perspective representation of the solid.

2. Find a point 1 foot to the right and 2 feet within. Give a perspective representation of a right line from this point touching the upper end of the cylinder, and which shall be in the same vertical plane as the axis of the cylinder.

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1. A flight of 5 steps—each step to be 1 foot rise and 1 foot tread, and 6 feet long. The nearest corner of the base touches the picture-line 4 feet to the left, its sides making an angle of 45 degrees with the picture-plane. The space between the ground line and horizontal line is 5 feet. By this scale the drawing may be wrought out.

2. Define vanishing-points and measuring-points.

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1. The base of a prism is an equilateral triangle of 5 feet side, its length being 8 feet. Put the prism in perspective with one side lying on the ground-plane, its long edges being inclined at 60 degrees to the picture-line towards the right, and the angle nearest the spectator being 3 feet on his left and 2 feet from the picture-line.

2. Draw a straight line crossing at right angles the upper edge of the prism midway from its ends, and meeting the ground-plane at an angle of 30 degrees.

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1. A rectangular prism 9 feet by 1 foot by 1½ foot is 3 feet from the picture-line and 2 feet to the spectator's right, the longest side vanishing to the left at an angle of 45 degrees.

2. This prism is the first of a flight of 3 steps.

3. Upon the top step place a semicircular arch. The diameter of the outer arc to be 9 feet and the inner one 6 feet, and to be of the same thickness as the step.

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1. The base of a rectangular solid is 3 feet square, length 8 feet. Put it in perspective when lying on one of its sides, when the longest edges incline to the right at 45 degrees to the picture-plane. The nearest angle is 3 feet to the left and 1 foot within the picture.

2. Across the middle of this and at right angles with it place a similar one in a horizontal position. Let the centre of the upper solid be vertically over that of the lower one.

PAPERS GIVEN TO SENIOR CANDIDATES AT THE CAMBRIDGE LOCAL EXAMINATIONS.

1. A regular hexagonal prism is 8 feet long, and the sides of the base are 4 feet long. Put it into perspective, its base resting on the ground-plane, and one of its vertical sides being in contact with the picture-plane 3 feet on the left of the spectator.

2. Put the same solid in perspective lying on one of its sides, one angle of the base being in contact with the picture 3 feet on the right of the spectator, and the plane of its base vanishing towards the left hand at an angle of 45 degrees with the picture.

3. Find the vanishing-line of a plane which intersects the picture in the picture-line, and is inclined upwards at an angle of 30 degrees with the ground-plane.

1. Put into perspective on the ground-plane a circle of 2 feet radius, its centre to be 2 feet on the right of the spectator and 2 feet within the picture.
2. Put into perspective a hexagonal pyramid of which the sides of the base are 2 feet, and the height 6 feet, standing on its base on the ground-plane. The centre of the base is 3 feet within the picture and 1 foot on the left of the spectator.
3. From the apex of the pyramid draw a line parallel to the picture, and at an angle of 45 degrees with the ground-plane. Show where it cuts the ground-plane and ascertain its length.

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1. Put into perspective a right cylinder 4 feet in diameter and 3 feet high. Let it stand on the ground-plane, the centre of its base being 3 feet from the picture line and 1 foot on the left of the spectator.
2. On the top of this cylinder place a cube of 5 feet edge. Let the centre of one face of the cube coincide with the centre of the cylinder, and let the vertical sides of the cube be at equal angles with the picture-plane.
3. Find the vanishing-line of vertical planes inclined towards the picture at 45 degrees towards the right hand.

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1. A right cone is 4 feet in diameter and 6 feet high. Put it into perspective standing on the ground-plane and touching the picture-line 2 feet on the right of the spectator.
2. A rectangular solid has a base 4 feet square and is 8 feet long. Put it into perspective lying on the ground-plane, its sides making angles of 60 degrees with the picture-plane towards the right hand. The angle nearest the spectator to be three feet on his left and 4 feet from the picture-line.
3. Find the horizontal vanishing-line of descending-planes at an angle of 60 degrees with the picture.
4. Write a definition of a vanishing-line.

PAPERS GIVEN TO JUNIOR CANDIDATES AT THE CAMBRIDGE LOCAL EXAMINATIONS.

1. Put into perspective on the ground-plane a square of which the sides are 4 feet long, and of which one side is on the picture-line below the point of sight.
2. Within the square in last problem inscribe a second square, the angles of which shall be in the sides of the first square.
3. Upon the square of problem 2 as a base, place a rectangular solid 6 feet high.

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1. Put into perspective a cube of 3 feet sides, one face to be in the ground-plane, and the vertical faces to be at angles of 60 degrees and 30 degrees with the plane of the picture. The angle nearest the spectator to be 1 foot on his right and 2 feet within the picture.
2. Find a point (*A*) on the ground plane 2 feet on the right of the spectator and 5 feet within the picture.
3. From point *A* draw lines to the picture-line, making angles of 30 degrees, and 45 degrees, and 60 degrees, respectively, with the picture.

1. Find a point (A) on the ground-plane 3 feet on the left hand of the spectator, and 1 foot from the picture-line; and a second point (B) 1 foot on the right of the spectator, and 2 feet from the picture line.

2. Join the points (A and B) and let it be the side of a square lying on the ground-plane beyond the line ($A B$).

3. Upon the square of last problem as a base, place a regular pyramid 6 feet high.

4. Write a definition of a measuring point.

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1. Put into perspective on the ground plane, a regular octagon of which the sides are 5 feet long. Let one side be in the picture line immediately below the point of sight or centre of vision.

2. On one of the two sides of the octagon which are perpendicular to the picture-plane, place in perspective a second octagon of the same dimensions in a vertical position.

3. From any point (A) in the picture line draw a horizontal line at an angle of 45 degrees with the picture-line, and on it find a point (B) 6 feet from its intersection with the picture.

QUESTIONS GIVEN TO SENIOR CANDIDATES AT THE OXFORD LOCAL EXAMINATIONS.

1. Explain the difference between an architectural and a perspective drawing of the same building.

2. What is meant by the plane of the picture?

3. What is the horizontal line? Is its position in a picture necessarily, fixed or is it optional?

4. Why must distant objects be represented as smaller than nearer ones of an equal size? In what proportion will they appear to diminish? Draw an illustration.

5. A pavement is composed of slabs of stones each 2 feet square. Circles of black marble 8 inches diameter are let in where the corners of the slabs meet. Draw a portion of this pavement, the nearest part of it being 12 feet distant from the place where you are standing and 5 feet below the level of the eye.

6. Draw a cube with its top above and its base below the horizontal line.

First. With one face parallel with the picture-plane.

Second. In an oblique position with a gable half the height of the side of the cube drawn upon one of its upper faces.

7. Explain (in problem 6) how to determine the position of the point of the gable.

8. Is the outline sufficient in all cases to express the form of an object? Illustrate this by a drawing of a concave or a convex hemisphere

9. In drawing a view of the open sea with buildings on the shore is the horizon of the sea a distinct line in clear weather? Why so?

10. What position will the line occupy in your picture? Will its position be the same if you draw the same view from a higher ground?

11. In what cases will parallel lines be represented as converging, and in what cases will they remain parallel? Give a drawing of an object to illustrate this.

12. How many planes are used in perspective drawing? Explain them.

13. A square building is supported by arches upon pillars. The points of the arches are 30 feet from the ground. Draw a view of part of two sides of the building in oblique perspective, giving 2 arches on one side and 3 arches on the other.

14. A barrel is 4 feet long and 2 feet in diameter at the ends and 2 feet 6 inches in the middle. It is bound by 6 iron hoops. Draw this barrel standing upright on the ground-plane, the centre of the circle on the ground being 3 feet on the right and 2 feet into the picture.